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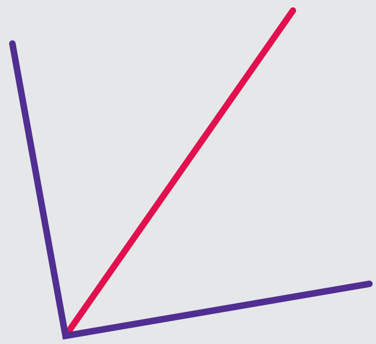

Maths in science

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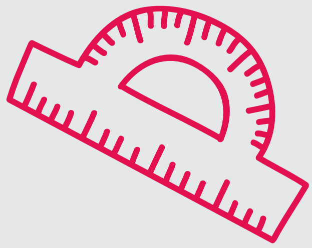
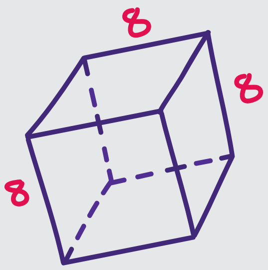
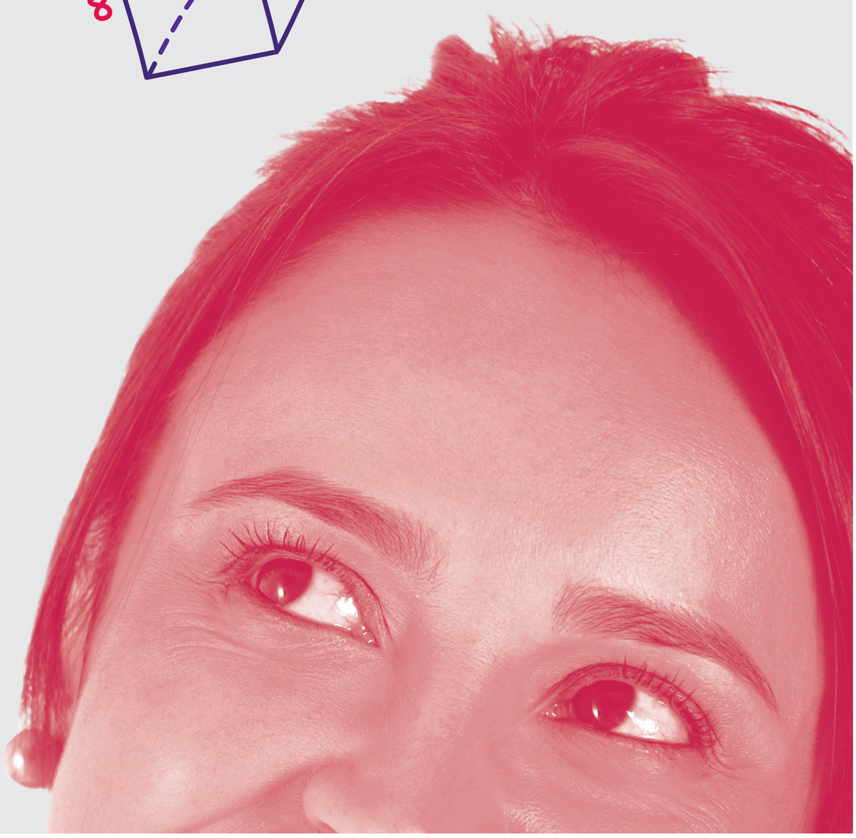




Activities booklet



Contents

Activity 1

Audit of maths skills

Individually consider each maths skill using the table on page 5 of this booklet.

Answer the following questions for each skill:

- how confident are you in teaching the underlying principles?
- could you differentiate your approach to teaching this skill to different ability groups?

Share your thoughts with the group.

As a group, identify which maths skills your students find challenging. If you have insight from the *Student maths skills audit*, include this in the discussion.

You may want to do this for three broad ability groups to help focus future intervention work.

Slides 7 and 8 list aspects of maths skills that have caused students issues in recent exams which may be of use in the discussion.

Teacher maths skills audit

Mathematical requirements	Level of confidence to teach	Challenge for students
1. Arithmetic and numerical computation		
1a. Recognise and use expressions in decimal form		
1b. Recognise and use expressions in standard form		
1c. Use ratios, fractions and percentages		
1d. Make estimates of the results of simple calculations		
2. Handling data		
2a. Use an appropriate number of significant figures		
2b. Find arithmetic means		
2c. Construct and interpret frequency tables and diagrams, bar charts and histograms		
2d. Understand the principle of sampling as applied to scientific data (Biology only)		
2e. Understand simple probability (Biology only)		
2f. Understand the terms mean, mode and median		
2g. Use a scatter diagram to identify a correlation between two variables (Biology and Physics only)		
2h. Make order of magnitude calculations		
3. Algebra		
3a. Understand and use the symbols: =, <, <<, >>, >, ∝, ~		
3b. Change the subject of an equation		
3c. Substitute numerical values into algebraic equations using appropriate units for physical quantities (Chemistry and Physics only)		
3d. Solve simple algebraic equations (Biology and Physics)		
4. Graphs		
4a. Translate information between graphical and numeric form		
4b. Understand that $y=mx+c$ represents a linear relationship		
4c. Plot two variables from experimental or other data		
4d. Determine the slope and intercept of a linear graph		
4e. Draw and use the slope of a tangent to a curve as a measure of rate of change (Chemistry and Physics only)		
4f. Understand the physical significance of area between a curve and the X-axis and measure it by counting squares as appropriate (Physics only)		
5. Geometry and trigonometry		
5a. Use angular measures in degrees (Physics only)		
5b. Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects (Chemistry and Physics only)		
5c Calculate areas of triangles and rectangles, surface areas and volumes of cubes		

Activity 2

Maths and science

For each of the examples below discuss:

- approaches and language used with students to help them access this type of question
- how this approach and language might be different in maths lessons
- whether there are any other skills that have different approaches or language used between the two departments
- how differences could be resolved.

Slide 12 summarises some of the differences in teaching approaches between maths and science that we are aware of. This list is not exhaustive and you might not have these differences in your school.

Graphs

Synergy 2018 3H Q7.1

Table 1 shows some of the teacher's results.

Table 1

Volume of hydrochloric acid added in cm^3	Temperature in °C
0	21.30
5	24.25
10	26.15
15	27.05
20	27.70

0 7 . 1 **Figure 4** shows the results when 30 cm^3 to 50 cm^3 of hydrochloric acid was added to sodium hydroxide solution.

A line of best fit has been drawn through these results.

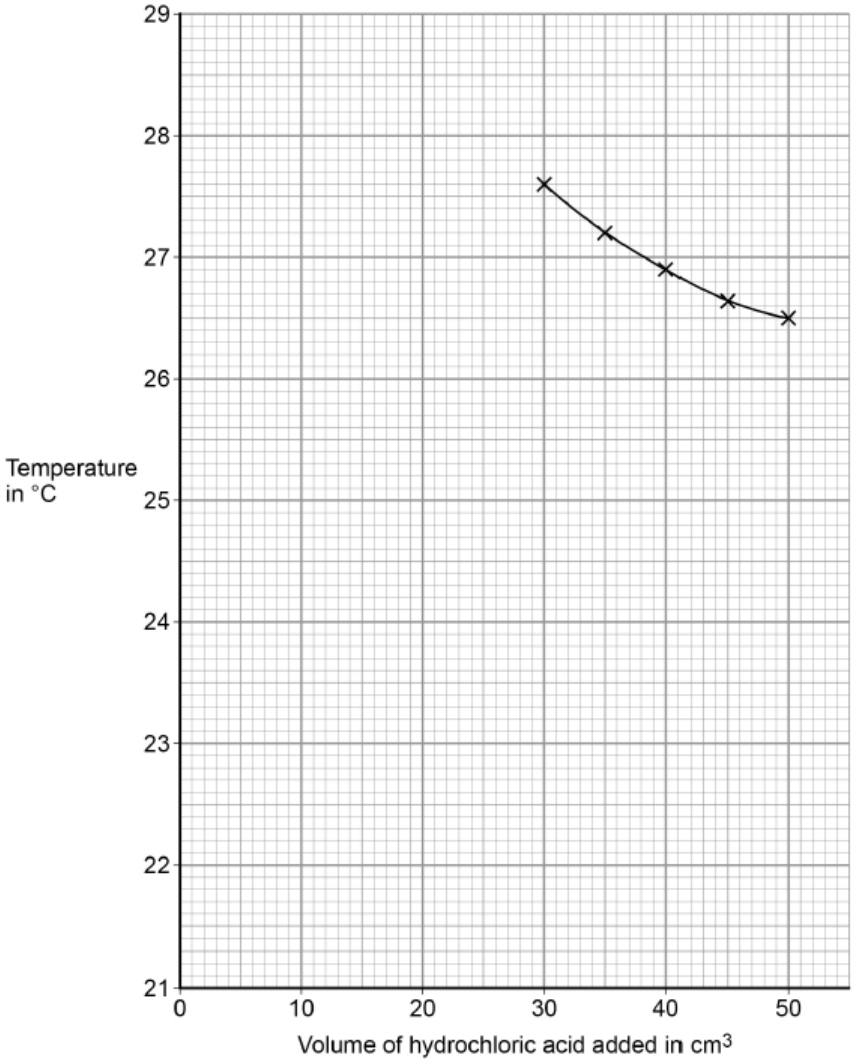
Complete **Figure 4**.

You should:

- plot the data from **Table 1** on **Figure 4**
- draw a line of best fit through these results
- continue both lines of best fit until the lines meet.

[4 marks]

Figure 4



07.1	all points correct line of best fit (0–20 cm^3 hydrochloric acid added) extrapolation of both lines to cross	allow a tolerance of ± half a small square allow **1** mark if 3 **or** 4 points are correct	2 1 1	AO2 4.7.3.3

Equations

Synergy 2018 4H Q1.6

The LDR was placed near a light source.

The following results were recorded:

potential difference = 5.50 V

current = 12.5 mA

0 1 . 5 Write down the equation that links current, potential difference and resistance.

[1 mark]

_____

0 1 . 6 Calculate the resistance of the LDR.

[4 marks]

_____

_____

_____

_____

_____

Resistance = _____ Ω

01.6		an answer of 440 (Ω) scores **4** marks an answer of 0.44 (Ω) scores **3** marks		AO2 4.7.2.2
	12.5 mA = 0.0125 A		1	
	5.50 = 0.0125 × R	this mark may be awarded if current is incorrectly / not converted	1	
	$(R =) \frac{5.50}{0.0125}$	this mark may be awarded if current is incorrectly / not converted	1	
	(R =) 440 (Ω)	allow an answer consistent with incorrectly / not converted current	1	

Percentages

Chemistry 2F 2018 Q9.2

0 9 Methylated spirit is a useful product made from a mixture of substances.

Table 6 shows the mass of the substances in a sample of methylated spirit.

Table 6

Substance	Mass in grams
Ethanol	265.5
Methanol	23.3
Pyridine	3.0
Methyl violet	1.5

0 9 . 2 Calculate the percentage by mass of methanol in methylated spirit.

Use **Table 6.**

[2 marks]

09.2	$\frac{23.3}{265.5 + 23.3 + 3.0 + 1.5}$ (× 100) = 7.9 (%)	an answer of 7.9 (%) scores **2** marks allow $\frac{23.3}{293.3}$ (× 100) allow 7.944084555 (%) rounded correctly	1 1	AO2 4.8.1.2

Percentage change

Synergy 2H 2018 Q6.1

Table 2 shows the results of the investigation.

Table 2

Student	Number of hours of sleep	Reaction time in milliseconds			
		Test 1	Test 2	Test 3	Mean
A	8	229.6	253.3	233.4	238.8
B	6	298.3	308.7	269.1	292.0
C	4	211.2	218.9	206.5	212.2
D	2	449.3	445.2	441.9	445.5
E	1	712.0	717.9	715.3	715.1

0 6 . 1 Calculate the percentage decrease in mean reaction time when the number of hours of sleep increases from 1 hour to 8 hours.

[2 marks]

06.1	(715.1 − 238.8 = 476.3) $\frac{476.3}{715.1}$ (× 100) 66.6 (%)	an answer of 66.6 (%) scores **2** marks allow correct rounding of 66.60606908	 1 1	AO2 4.2.1.6

Activity 3

Diagnostic questions

Below are two examples of how an exam question can be edited to make it into a diagnostic question. The purple boxes within the question show how it has been amended. The boxes to the side show the maths skill being targeted.

As a group, look at the two examples:

- discuss if you think this approach might be helpful as a starting point to gauge each student's level of competency for a particular skill
- using the Physics question on momentum, edit the question so it could be used to quickly assess students' ability to tackle equations generally, rather than assess understanding of momentum
- discuss if there are any other maths skills you could incorporate into the equation question.

The *Diagnostic question examples* table found in the Appendix lists other suggested questions from 2018 that might be useful to edit as diagnostic questions.

As a group, familiarise yourselves with some of the common misconceptions and errors we have seen in the *Misconceptions and common errors* table found on pages 18–21.

Discuss what strategies you could use to help address these common misconceptions.

Biology 1F 2018 Q8

16 marks, 16–20 mins, 6 maths skills

0 8 Metabolism is the sum of all the chemical reactions in the cells of the body.

One metabolic reaction is the formation of lipids.

~~**0 8 . 1** Give **one** other metabolic reaction in cells.~~

~~**[1 mark]**~~

A simple stem, setting the context. Students don't need to know anything about metabolism so Q8.1 has been removed.

Table 5 shows the mean metabolic rate of humans of different ages.

Table 5

Age in years	Mean metabolic rate in kJ/m^2/hour	
	Males	Females
5	53	53
15	45	42
25	39	35
35	37	35
45	36	35

0 8 . 2 What **two** conclusions can be made from the data in **Table 5**?

[2 marks]

2c
2f

Tick **two** boxes.

- As age increases, mean metabolic rate of males and females increases. ☐
- Males have a higher metabolic rate than females after five years of age. ☐
- The mean metabolic rate of females decreases faster than males up to 25 years of age. ☐
- The mean metabolic rate of males and females decreases more quickly after the age of 35. ☐
- There is no relationship between age and mean metabolic rate. ☐

0 8 . 3 Calculate the percentage decrease in the mean metabolic rate of males between 5 years and 45 years of age.

1a
2c
3a

Use the equation:

$$\text{percentage decrease} = \frac{\text{decrease in metabolic rate}}{\text{original metabolic rate}} \times 100$$

Give your answer to 3 significant figures.

[3 marks]

To differentiate, remove the equation.

Regular exercise can increase metabolic rate.

Two people did five minutes of gentle exercise from rest.

Table 6 shows the effect of the exercise on their heart rates.

Table 6

Time in minutes	Heart rate in beats per minute	
	Person R	Person S
0 (at rest)	60	78
1	76	100
2	85	110
3	91	119
4	99	129
5	99	132

0 8 . 4 Describe **two** differences in the response of person **R** and person **S** to the exercise.

2c
4a

Use information from **Table 6**.

[2 marks]

0 8 . 5 Complete the line graph in **Figure 12** for person **S**.

4a
4c

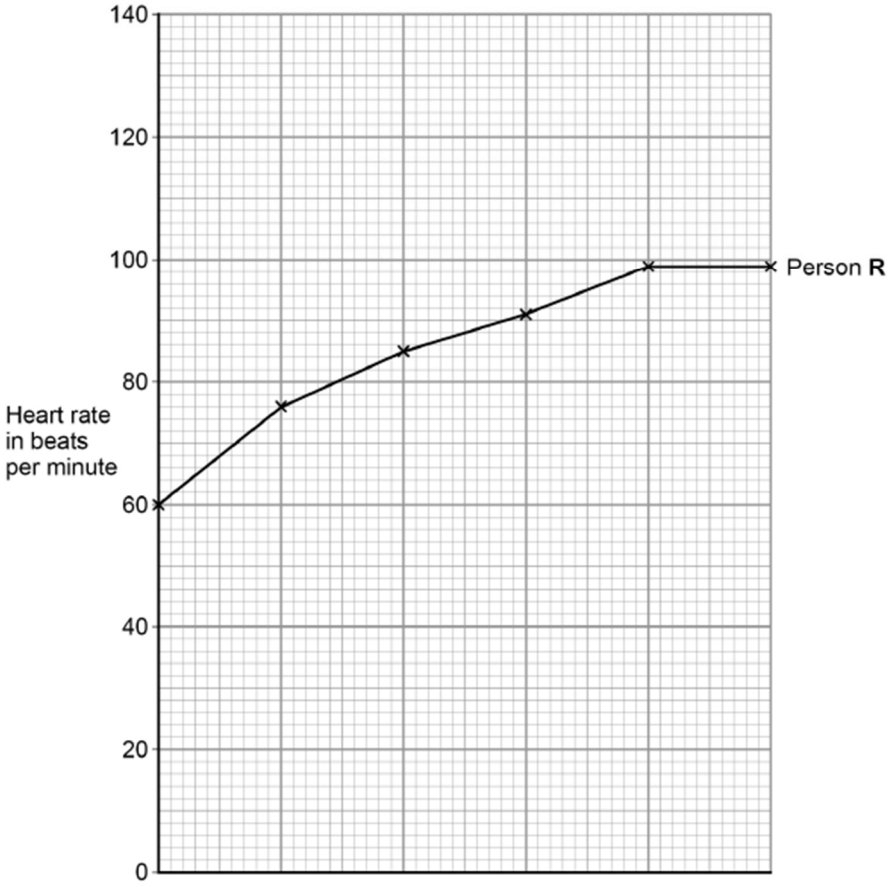
You should:

- add the scale to the x axis
- label the x axis.

[4 marks]

(Continued on next page)

Figure 12



To differentiate, remove the scale on the Y axis and the plot of Person R; ask students to construct a graph to show the pattern in the data for both Person R and S.

0 8 . 6 After five minutes of exercise, the heart rate of person **S** was 132 beats per minute. When person **S** rested, his heart rate decreased steadily at a rate of 12 beats every minute.

Calculate how much time it would take the heart rate of person **S** to return to its resting rate.

[2 marks]

1c

0 8 . 7 A student made the following hypothesis about the heart rate of smokers and non-smokers during exercise.

"During exercise, the heart rate of smokers increases more than the heart rate of non-smokers."

Design an investigation that would allow you to test this hypothesis.

[6 marks]

2d

Reword to focus on controls for the two populations selected for the sample rather than designing the whole investigation [3 marks].

Trilogy Chemistry 2F 2018 Q4

7 marks, 10 minutes, 3 maths skills

0 4 A 9 carat gold ring is made from a mixture of metals.

Table 3 shows the mass of different metals in the ring.

The mass of the ring is 5.0 g

Table 3

Metal	Mass of metal in g
Gold	1.9
Silver	2.8
Copper	0.3

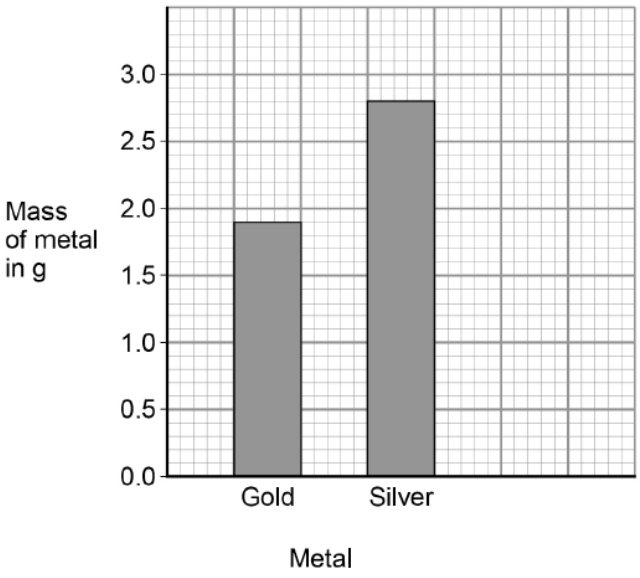
Familiar, simple context.

0 4 . 1 Plot the data for copper from **Table 3** on **Figure 1.**

[2 marks]

4a

Figure 1



To differentiate, ask students to plot a bar chart of the data shown in table 3 (award 4 marks: suitable scale [1], accurate plotting [2], labelled axis [1]).

0 4 . 2 The cost of gold is £30 per gram.

1a

Calculate the cost of the gold used in the 9 carat gold ring.

Use **Table 3.**

[1 mark]

To differentiate, change cost of gold to include a decimal, eg £27.40.

0 4 . 3 Rings can be made from 22 carat gold.

1c

The ratio of the mass of gold in 22 carat gold compared to 9 carat gold is 22 : 9

Calculate the mass of gold in a 22 carat gold ring of mass 5.0 g

Use **Table 3.**

[2 marks]

Q4.3 offers an opportunity to explain to students what ratios mean and to calculate a simple ratio.

Trilogy Physics 2H 2018 Q3

0 3 **Figure 5** shows an ice skater, Skater **A**.

Figure 5

0 3 . 1 Write down the equation that links mass, momentum and velocity.

[1 mark]

_____

0 3 . 2 Skater **A** travels with a velocity of 3.2 m/s and has a momentum of 200 kg m/s

Calculate the mass of Skater **A**.

[3 marks]

_____

_____

Mass = _____ kg

Misconceptions and common errors

Maths skill	Common misconceptions and errors
Arithmetic and numerical computation	
1a. Recognise and use expressions in decimal form	Students need to be shown how the position of each digit in the number determines the size of the number (place value). Most misconceptions occur when converting between decimals and fractions or decimals and percentages, eg a student might think that 0.12 = 1/12 or 0.5 = 5%.
1b. Recognise and use expressions in standard form	Students typically find it difficult remembering whether positive powers of ten relate to large numbers or small numbers as they recall a process rather than linking it to place value. The use of index notation within standard form makes routine problems look more difficult and students can be reluctant to attempt the questions, even though they know how to do them.
1c Use ratios, fractions and percentages	Students will need to be reminded of the following: • ratios are not the same as fractions, ie 4:7 does not mean 4/7 • we expect the answer to be reduced to the smallest ratio possible rather than the raw numbers. For instance, if a ratio works out as 12:6 we would expect it to be given as 2:1 • we don't use fractions often but students might need to understand that a value in a question is a fraction of another value and to use the value of that fraction to do a calculation • finding 10% of a number is the only percentage where you can divide by it to find the percentage, ie 10% is the same as divide by 10 but 20% is not the same as divide by 20 • percentage change is not listed in the DfE criteria for maths but it is required as part of the content in Biology and Chemistry. Students often don't know how to calculate it and confuse the equation. $= \frac{\text{difference between 2 values}}{\text{original value}} \times 100$
1d Make estimates of the results of simple calculations	Estimations in science require students to look at some given data and make a sensible estimation of what a missing value in the data might be. This might be when they extrapolate a line on a graph or to give the intermediate value in a set of data, for example given the volume of gas given off at 10, 20, 30, 40, 50 degrees and asked to estimate what the value at 45 might be. Students sometimes try to do exact calculations rather than estimate showing a lack of understanding of the term. In maths, it means rounding up or down to 1 significant figure before doing a calculation.
Handling data	
2a Use an appropriate number of significant figures	Students mix up decimal places and significant figures thinking they are the same thing. Students often don't understand **why** they are being asked to put a number to a particular significant figure.

	They need to understand that their answer should be given to the same significant figures as the data they are given in the question. So, if all the data was given to 3 significant figures (1.27, 4.56, 3.75 etc) then the answers also would be to 3 significant figures. The data in the question will help them know what it looks like. If there are 'leading zeros' in a number, students can forget to ignore them when showing a number to a specific number of significant figures.
2b Find arithmetic means	Most students are able to calculate means and understand the term. The most common error is that students often forget to exclude anomalous results even when instructed to. This suggests that it is the term 'anomalous result' they don't understand or the significance of an anomalous result when taking and recording readings.
2c Construct and interpret frequency tables and diagrams, bar charts and histograms	In science, the emphasis is more likely to be on the interpretation than on the construction of tables. When calculating a mean from frequency tables, they should divide by total frequency not the number of rows. When drawing bar charts, some students do not evenly space the bars out, or keep them at a constant width, drawing something somewhere between a bar chart and a histogram. Examiners are generous in marking these, but it is worth reminding students that the bars should be: • evenly spaced out • be of a consistent width • labelled clearly. Although not assessed, you might want to explain the difference between a bar chart and a histogram as maths make more of the difference. Students will need to recognise and interpret pie charts and most students are competent with this.
2d Understand the principle of sampling as applied to scientific data (Biology only)	Students need to identify sensible and relevant variables/factors that need to be considered when selecting a sample population so that the sample will give viable results. Students often don't understand why we use random sampling to collect data (to avoid bias, to support collection of valid data). This links with estimation as students need to appreciate that sampling involves an estimate rather than an exact calculation.
2e Understand simple probability	Science would accept a probability given as a ratio, a fraction or a percentage.
2f Understand the terms mean, mode and median	With groups of data, students will sometimes divide by how many groups there are rather than the total frequency. When calculating the median, they may forget to put the data in order first and may confuse the answer for the median with its position in the sequence.
2h Make order of magnitude calculations	Errors tend to occur with mixing up which way to do the conversions, eg a student might convert 2m to 2000km rather than 0.002km. Students try to include cm in order of magnitude sequences, rather than just mm-m-km, as they are so familiar with working in cm. Some students just multiply or divide everything by a 100 regardless.

2g Use a scatter diagram to identify a correlation between two variables	Students will need to be reminded that correlation is not causation. Just because two variables appear to be correlated on a scatter graph, does not mean that one actually affects or is affected by the other.
Algebra	
3a Understand and use the symbols: =, <, <<, >>, >, ∝, ~	<, <<, >>, > are not used often. Some student do not recognise ∝ symbol.
3b Change the subject of an equation	If using a formula triangle, students must write out the correctly rearranged equation. The triangle by itself is not enough.
3c Substitute numerical values into algebraic equations using appropriate units for physical quantities	There is no rule in science about which comes first, substitution or rearranging. AQA convention in mark schemes is to show rearranging then substitution, but if the examiner can clearly see that the student has done both steps and it is **correct** then both marks will be awarded, if appropriate. We encourage students to substitute and then rearrange because if they rearrange incorrectly first, they cannot gain the substitution mark either. If they substitute correctly first, they can be awarded this mark even if they go on and rearrange the equation incorrectly. A common error is to not convert units correctly before substituting – eg put a value in grams when it should have been converted to kg.
3d Solve simple algebraic equations	Common issues include: • not using a calculator to do calculations • not showing their working • sometimes students round at each step in a multistep calculation rather than just at the end which introduces errors.
Graphs	
4a Translate information between graphical and numeric form	Common errors include: • confusing the X and Y axes. • not realising how much one square represents • misreading the scale especially in more complex numbers for example • missing the part in the legend for the axis that says, for example, in thousands.
4b . Understand that $y=mx+c$ represents a linear relationship	Confusion between what is meant by directly and inversely proportional.
4c Plot two variables from experimental or other data	Some students: • don't understand that the scale divides the axis up into equal parts. Instead they use one set of the data shown in the results table as the scale • have difficulty working out what each small square represents on the scale. Labels for the axis should be taken from the titles of the columns of the results table. If 0:0 is given in the results table, then this point needs to be plotted and the line of best fit should go through the origin. Not all lines of best fit are straight they may be a curve. Some students continue the line beyond the points plotted when this is not needed and doesn't make sense to do.

4d Determine the slope and intercept of a linear graph	Problems include: • getting the values upside down when calculating a gradient of a linear graph • drawing the line of best fit from the origin, not from the intercept.
4e Draw and use the slope of a tangent to a curve as a measure of rate of change	Students need to be careful where they draw the tangent to the curve as, if it's not accurate, they could get a gradient that's out of the tolerance allowed in the mark scheme.
4f Understand the physical significance of area between a curve and the X-axis and measure it by counting squares as appropriate	Student responses to questions about areas under a curve can reveal misconceptions about the subject of the graph. For example, in a velocity or speed versus time graph, it is not always understood that the area under the line represents the distance travelled in that time.
Geometry and trigonometry	
5a Use angular measures in degrees (Physics only)	Some students find measuring using rulers and protractors quite challenging. Some students think that a larger diagram indicates a larger angle.
5b Visualise and represent 2D and 3D forms including two dimensional representations of 3D objects (Chemistry and Physics only)	Students need to understand that models are a best fit approach.
5c Calculate areas of triangles and rectangles, surface areas and volumes of cubes	If an irregular shape is shown, students need to understand that they can split it up into squares and triangles to calculate overall areas. They often confuse perimeter with area.

Activity 4

Curriculum planning

Ideally use your own school's maths and science curriculum route maps for this activity. If your school doesn't have curriculum route maps, we've included generic AQA examples for maths and science in the additional PowerPoint, *Editable curriculum route maps*. These can be easily edited to reflect the teaching at your school prior to this session.

Compare the maps and then annotate your science curriculum plan for each maths skill to show if science teachers need to teach the skill first because it is not already covered in maths.

Discuss any timing issues.

Refer to your electronic SOW and review the lessons where the maths opportunities first arise. See if they are appropriate now you have this timing knowledge.

While you are doing this, consider the questions below.

- Am I teaching this for the first time building on KS3 knowledge?
- Am I revising the skill with students building on their experience in maths GCSE?
- Am I embedding the skills introduced earlier in a different science topic?

If there's time, review the SOW to see if there are any more good opportunities you can add.

Activity 5

Applying a mark scheme

Please note that the example student responses used in this section have been re-written for copyright purposes.

Look at the examples below.

Using the mark scheme provided, mark the student responses showing where you award each marking point.

Discuss with the group where the marks were awarded and address any misconceptions teachers may have about how calculations are awarded marks.

Compare your marking to the examiner reports and commentaries for Activity 5 found in the Appendix.

Biology 2H 2018 Q7.2

0 7 . 2 Calculate the percentage of the biomass lost between the algae and the large fish.

Give your answer to 2 significant figures.

[3 marks]

Mark scheme

07.2		an answer of 99 scores **3** marks		AO2 4.7.4.3
	$\frac{840 - 10}{840} \times 100$	allow equivalent calculation	1	
	98.809523... / 98.810 / 98.81 / 98.8		1	
	99	allow answer given to two significant figures from an incorrect calculation in step 2	1	

Script A

Give your answer to 2 significant figures.

[3 marks]

$\frac{200}{840} \times 100 = 23.8\%$

$100 - 23.8\% = 76.19\%$

Percentage loss = 76

Script B

Give your answer to 2 significant figures.

[3 marks]

$840 - 10 = 830.$

$\frac{10}{840} \times 100 = 1.190476$

$100 - 1.190476 = 98.809523$

Percentage loss = 99 %

Trilogy Chemistry 1H 2018 Q8.3

Magnesium reacts with iron chloride solution.

$$3\ Mg + 2\ FeCl_3 \rightarrow 2\ Fe + 3\ MgCl_2$$

0 8 . 3 0.120 g of magnesium reacts with excess iron chloride solution.

Relative atomic masses (A_r): Mg = 24 Fe = 56

Calculate the mass of iron produced, in mg

[5 marks]

Mark scheme

08.3		an answer of 185–190 (mg) scores **5** marks an answer of 0.185–0.19 scores **4** marks		AO2 5.3.2.2
	(Mg) $\frac{0.12}{24}$ or 0.005 (moles)	mark is for ÷ by 24	1	
	(Fe) $\frac{2}{3} \times 0.005 = 0.00333$(moles)	mark is for $\times \frac{2}{3}$	1	
	(mass Fe) = 0.00333 × 56	mark is for × 56	1	
	= 0.1866 (g)		1	
	= 187 (mg)		1	
		an answer of 280 (mg) scores **4** marks an answer of 0.280 scores **3** marks (no ratio from equation) 184 scores **0** [=(3×24) + (2×56)]		
	OR (Mg) = $\frac{0.12}{(3 \times 24 =)\ 72}$ (1) = 0.00166 **or** $\frac{1}{600}$ (moles) (1) (mass of Fe) = 0.00166 **or** $\frac{1}{600} \times 112\ (2 \times 56)$ (1) = 0.1866 (g) (1) 187 (mg) (1)			

08.3 cont.	**OR** 72 g Mg → 112g Fe (1) 1 g Mg → $\frac{112}{72}$ **or** 1.56 g Fe (1) 0.12 g Mg → $\frac{112}{72}$ × 0.12 (1) = 0.1866 (g) (1) = 187 (mg) (1)			

Script C

Calculate the mass of iron produced, in mg

[5 marks]

72 ÷ 0.120

112 ÷ 600 = 0.186

24 x 3 = 72

56 x 2 = 112

Mass of iron = 0.186 mg

Script D

Calculate the mass of iron produced, in mg

[5 marks]

24 + 56 = 80

$\frac{0.120}{24}$

Mass of iron = 500 mg

Script E

Calculate the mass of iron produced, in mg

[5 marks]

Ar of Mg = (24 x 3) = 72

Mole of Mg = $\frac{0.120}{72}$ = 0.0016

Ar of 2 $FeCl_3$ = 2 x (56) + (6x

Mass of iron = _____ mg

Synergy 4H 2018 Q7.3

0 7 . 3 The lunar rover used four electric motors connected in parallel to a 36 V battery.

The maximum output power of one motor was 190 W

The efficiency of each motor was 72%

Calculate the current drawn from the battery when all four motors were operating at maximum power.

[6 marks]

Mark scheme

07.3		an answer of 29 (A) scores **6** marks		AO2 4.7.2.7 4.8.2.7
	$0.72 = \frac{190}{P_{input}}$	allow $\frac{72}{100} = \frac{190}{P_{input}}$	1	
	$P_{input} = \frac{190}{0.72}$		1	
	$P_{input} = 264$ (W)	allow an answer that rounds to 264 (W)	1	
	$264 = 36 \times I$	allow their calculated $P_{input} = 36 \times I$	1	
	$I = 7.33$ (A)		1	
	$I = 29$ (A)	allow an answer that rounds to 29 (A) allow their value for $I \times 4$ correctly calculated	1	

Script F

Calculate the current drawn from the battery when all four motors were operating at maximum power.

[6 marks]

$V = Ir$ $P = I^2r$ $P = IV$

$190 \times 4 = 760$ $760 \div 0.72 = 1055.\dot{5}$

$P = 1055.\dot{5}$

$(1055.\dot{5} = 36 \times I) = (I = 1055.\dot{5} \div 36) = 29.32$

Current = 29.32 A

Script G

Calculate the current drawn from the battery when all four motors were operating at maximum power.

[6 marks]

Current =

$190 \times 4 = 760w$

$760 \times 36 = 27360$

$7290 = 27360 \times 0.72 =$

19699.2

$27360 - 19699.2 = 7760.80$

Current = 7760.8 A

Script H

Calculate the current drawn from the battery when all four motors were operating at maximum power.

[6 marks]

190 - 27% = 138.7

138.7 x 4 = 554.8

4 motors = 554.8w efficiency

554.8w ÷ 36v = 15.41 ✓

554.8w x 36v = 19972.8 x

554.8 + 36 = 590.8

Current = 590.8 A

Chemistry 2H 2018 Q8.3

0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

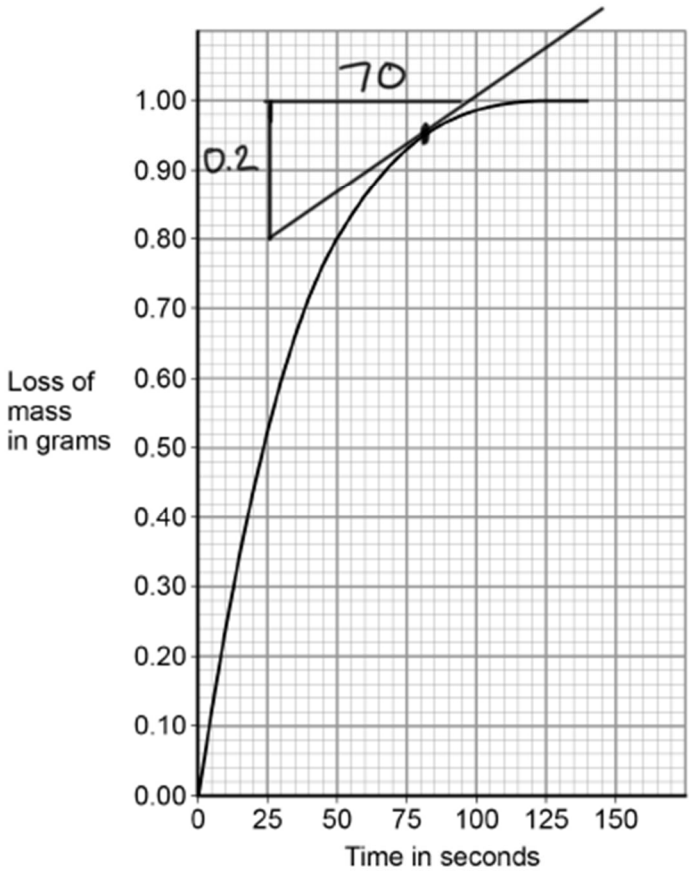
Mark scheme

08.3		an incorrect answer for one step does not prevent allocation of marks for subsequent steps		AO2 4.6.1.1
	correctly drawn tangent at 0.95 g		1	
	correct value for x step **and** y step from tangent	allow evidence of use of two points on tangent either on the graph or in the text	1	
	(rate =) $\frac{\text{value for y step}}{\text{value for x step}}$		1	
	correctly evaluated and rounded to 2 sig figs	allow (rate =) $\frac{\text{value for x step}}{\text{value for y step}}$ (ie inverted division) correctly evaluated and rounded to 2 sig figs	1	

Script 1

Figure 7 shows the student's results for hydrochloric acid at 50 °C

Figure 7



0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

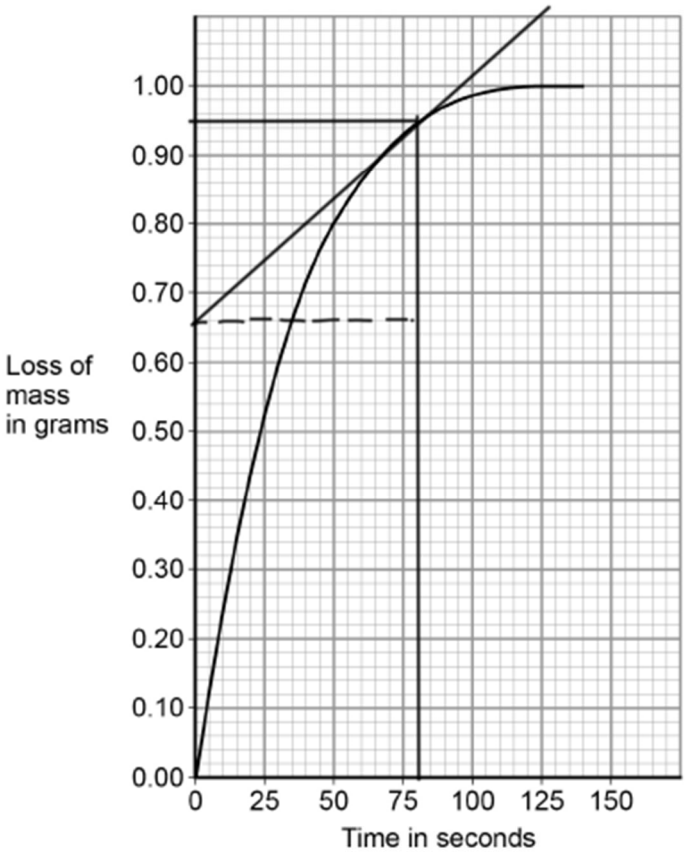
$\frac{\Delta y}{\Delta x} = \frac{0.2g}{95.25s} = \frac{0.2g}{70s} = 0.00285714$

Rate of reaction = _____ g/s

Script J

Figure 7 shows the student's results for hydrochloric acid at 50 °C

Figure 7



0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

80 × 0.95 = 76 g/s

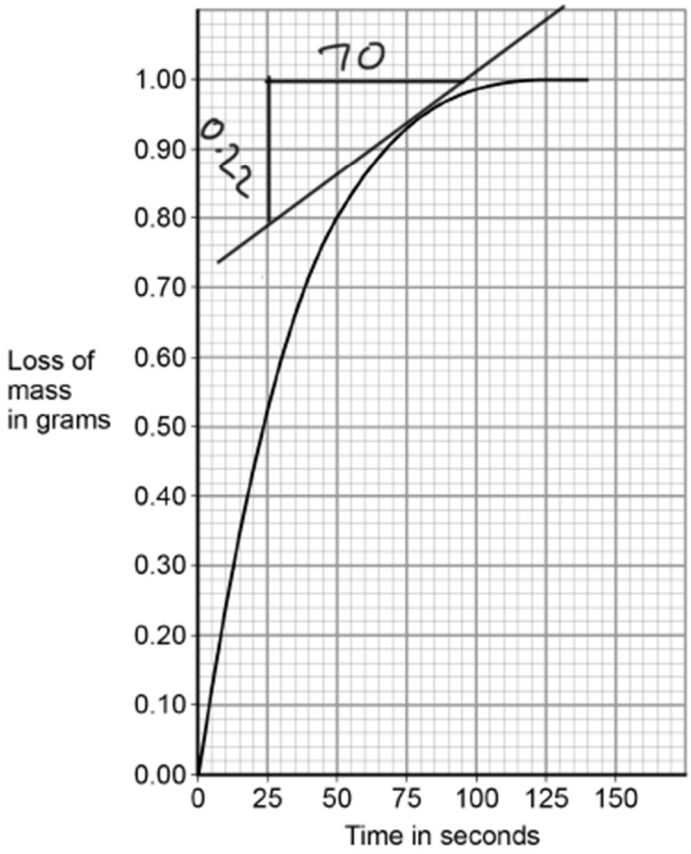
30 / 80 = 0.375 g/s

Rate of reaction = 76 g/s

Script K

Figure 7 shows the student's results for hydrochloric acid at 50 °C

Figure 7



0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

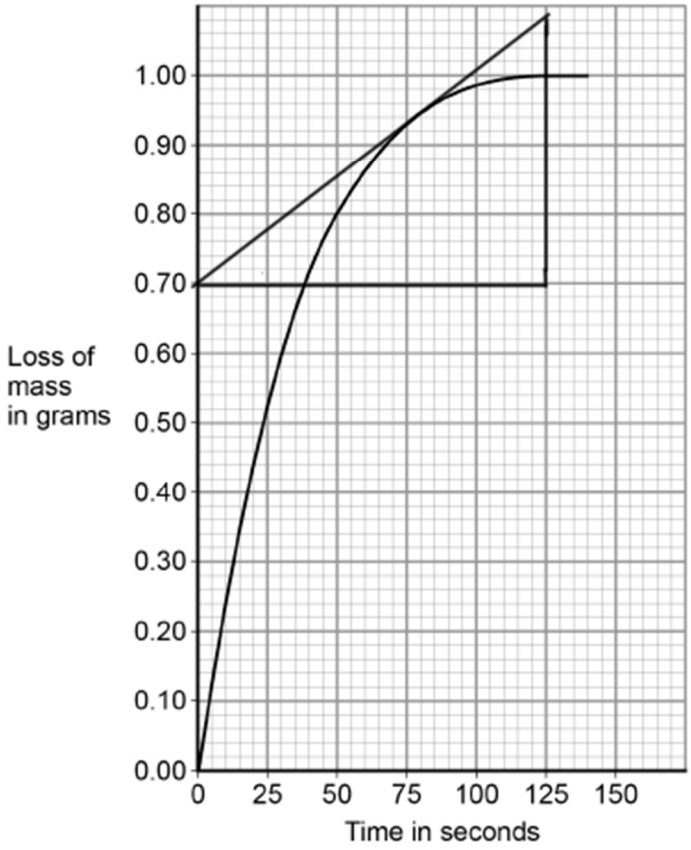
$\frac{0.22}{70} = 0.003142857$

Rate of reaction = 0.003 g/s

Script L

Figure 7 shows the student's results for hydrochloric acid at 50 °C

Figure 7



0 8 . 3 Determine the rate of reaction at 50 °C when the loss of mass is 0.95 g

Show your working on **Figure 7**.

Give your answer to 2 significant figures.

[4 marks]

$1.08 - 0.7 = 0.38$ g 125 seconds

$0.38 \div 125 = 3.04 \times 10^{-3}$

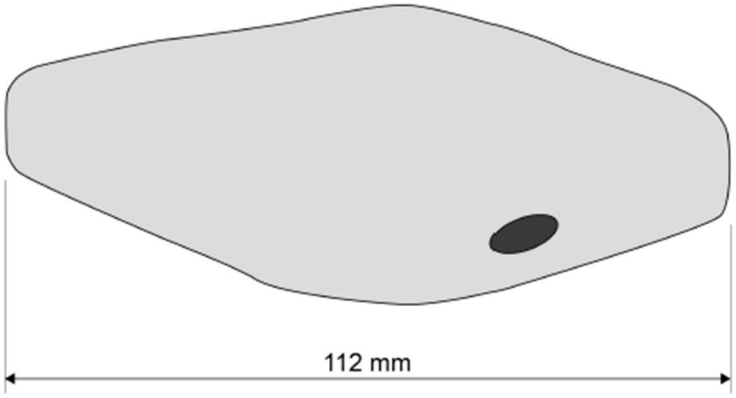
Rate of reaction = 3.04×10^{-3} g/s

Trilogy Biology 1F 2018 Q6.5 (1H Q1.5)

0 6 . 5 The student made the necessary adjustments to get a clear image.

Figure 13 shows the student's drawing of one of the cells.

Figure 13



The real length of the cell was 280 micrometres (μm).

Calculate the magnification of the drawing.

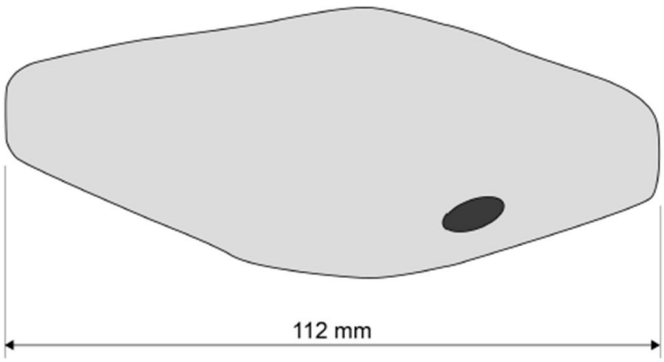
[3 marks]

Mark scheme

06.5		an answer of 400 (×) scores **3** marks		AO2 4.1.1.2
	conversion of units: (112 mm →) 112 000 (μm) **or** (280 μm →) 0.28 (mm)		1	
	(magnification =) $\frac{112}{0.28}$ **or** (magnification =) $\frac{112\,000}{280}$	allow **1** mark for no conversion of units 112 / 280 **or** incorrect value from step 1 correctly substituted	1	
	400 (×)	do **not** accept if units are given	1	
		if no other mark scored allow **1** mark for: magnification = $\frac{\text{size of image}}{\text{size of real object}}$ a triangle with words or letters in is insufficient, as the correct rearrangement is needed		

Script M

$\frac{1}{M \times R}$



The real length of the cell was 280 micrometres (µm).

Calculate the magnification of the drawing.

[3 marks]

~~$M = \frac{112}{280}$~~ ~~$280 \div 10000 = 0.028\text{mm} = 2.8\text{mm}$~~

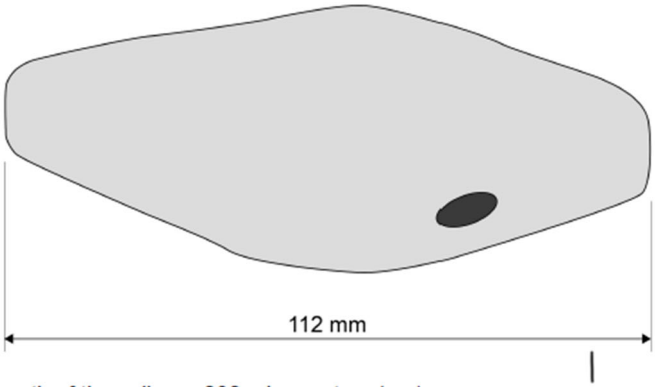
$280 \div 10000 = 0.028\ mm$

$= 0.4$

$M = \frac{112}{0.028} = 4000$

Magnification = × 4000

Script N



The real length of the cell was 280 micrometres (µm).

$\frac{1}{M}$ A

Calculate the magnification of the drawing.

[3 marks]

$\text{magnification} = \frac{\text{image size}}{\text{actual size}}$

$112 \div 280 = 0.4\ \mu m/mm$

Magnification = × 0.4 µm/mm

Trilogy Physics 2H 2018 Q5.2

0 5 . 2 The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

[3 marks]

Mark scheme

05.2		an answer of 0.063 (m) scores **3** marks		AO2 6.6.1.2
	$3.0 \times 10^8 = 4.8 \times 10^9 \times \lambda$	allow $\lambda = \frac{3.0 \times 10^8}{4.8 \times 10^9}$ this mark may be awarded if the standard form values are incorrectly converted	1	
	$\lambda = 0.0625$ (m)		1	
	$\lambda = 0.063$ (m) **or** $\lambda = 6.3 \times 10^{-2}$ (m)	allow an answer to 2 sig figs that is consistent with their calculated value of λ and has required rounding	1	

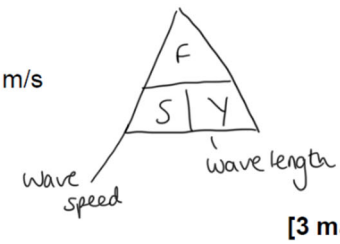
Script 0

0 5 . 2 The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.



[3 marks]

$f = s \times y$

$4.3 \times 10^9 = 3.0 \times 10^8 \times ?$

$\frac{4.3 \times 10^9}{3.0 \times 10^8} = 16$

Wavelength = 16 m

Trilogy Physics 2F 2018 Q5.5/Q5.6

When a force is applied to a spring, the spring extends by 7.5 cm

0 5 . 5 Write down the equation that links extension, force and spring constant.

[1 mark]

0 5 . 6 Calculate the force applied to the spring.

The spring has a spring constant of 1 600 N/m

Use your equation from question **05.5**

[3 marks]

Mark scheme

05.5	force = spring constant × extension	allow F = *k e*	1	AO1 6.5.3
05.6		an answer of 120 (N) scores **3** marks an answer of 12 000 (N) scores **2** marks		AO2 6.5.3
	7.5 cm = 0.075 m		1	
	F = 1 600 × 0.075	this mark may be awarded if e is incorrectly / not converted	1	
	F = 120 (N)	allow an answer that is consistent with their value of e	1	

Script P

When a force is applied to a spring, the spring extends by 7.5 cm

0 5 . 5 Write down the equation that links extension, force and spring constant.

[1 mark]

Spring constant = force x extension

0 5 . 6 Calculate the force applied to the spring.

The spring has a spring constant of 1 600 N/m

Use your equation from question **05.5**

[3 marks]

1600 x 7.5 =

Force = 12 000 N

Physics 2H 2018 Q2.5

Table 1

Force in N	Extension in cm
0	0.0
2	3.5
4	8.0
6	12.5
8	16.0
10	20.0

0 2 . 5 Calculate the spring constant of the spring that the student used.

Give your answer in newtons per metre.

[4 marks]

Mark scheme

02.5		an answer of 50 scores **4** marks		
	extension = 0.2	allow 0.035 / 0.08 / 0.125 / 0.16	1	AO2
	10 = k × 0.2	force value must match extension this mark may be awarded if e is in cm	1	AO2
	$k = \frac{10}{0.2}$	allow correct transformation of their chosen values this mark may be awarded if e is in cm	1	AO2
	k = 50	an answer 0.5 scores **3** marks	1	AO2 4.5.3

Script Q

0 2 . 5 Calculate the spring constant of the spring that the student used.

Give your answer in newtons per metre.

[4 marks]

F = 0 + 2 + 4 + 6 + 8 + 10 = 30 K = ?

E = 0.0 + 3.5 + 8.0 + 12.5 + 16.0 + 200

F = KE $\frac{30}{60} = K$ = 60

$\frac{F}{E} = K$ K = 0.5

Spring constant = 0.5 N/m

Activity 6

Assessment principles

For each of the following skill areas, work through pages 42–70 of this booklet.

- Using expressions in standard form
- Using an appropriate number of significant figures
- Graphing skills
- Equations

Familiarise yourselves with each skill's assessment design principles and typical exam requirement for each level of demand. These are set out below.

Mark the student responses and discuss:

- what level of demand the question is and why
- what the common errors are
- what possible strategies you could use with the students to overcome them.

Having completed all the skill areas, think about each of your different teaching sets. Discuss what the appropriate learning would be for them to ensure concrete learning and progression.

Recognise and use expressions in standard form

General principles

- Standard form is Foundation content at GCSE Maths, so in GCSE science we would expect to assess it at standard demand or above. This means that questions involving standard form could appear on a Foundation tier paper, especially if the question is one that is common with the Higher tier paper.
- If a question says 'give your answer in standard form', there is a mark for the correct standard form. This mark will be at least standard demand, and probably standard/high or high demand, depending on the numbers involved and the rest of the calculation.
- As well as requiring students to use standard form in a calculation we might:
  - ask for an answer from one question (eg question 2.2) to be converted into standard form in the next question (eg 2.3)
  - give a number and ask students to state what it would be in standard form (this is likely to be in the form of a multiple-choice question).
- Many students don't make an attempt at putting their answer in standard form. So, to help students who miss or forget the instruction earlier in the question, from Summer 2020 it will be repeated on the answer line to remind them. For example:

  Acceleration (in standard form) = _____

Progression of demand in assessment of standard form

The table below shows how the features of GCSE science assessments, on the use of standard form, progress from low to high demand.

How could you support your students operating at each of these levels of demand?

Low demand (Foundation tier only)	Standard demand (Foundation and Higher tier)	High demand (Higher tier only)
Use of standard form will not be assessed at low demand	An answer will be required in standard form	An answer will be required in standard form
	Numbers will be given as positive (eg $\times 10^{6}$) indices	Numbers will use positive (eg $\times 10^{6}$) **or** negative (eg $\times 10^{-6}$) indices
	Students expected to convert large or small numbers to standard form	Students expected to convert large or small numbers to standard form
	Students **not** expected to carry out calculations using numbers in standard form	Students **are** expected to carry out calculations using numbers in standard form

Example student responses

Example 1

Mark scheme

04.2		an answer of 3.3×10^5 scores **5** marks an answer of 330 000 scores **4** marks		AO2 4.7.2.1
	(correct mean per m^2 =) 6 or 6.0		1	
	(correct field area =) 55 000 (m^2)		1	
	mean x area – eg 6(.0) × 55 000	allow incorrect calculated values for mean and / or field area	1	
	330 000	allow correct calculation from previous calculation	1	
	3.3×10^5	allow calculated value in standard form	1	

Student R

0 4 . 2 Estimate the total number of dandelion plants in the field.

Calculate your answer using information from **Figure 5** and **Table 2**.

Give your answer in standard form.

[5 marks]

100 x 100 = 10 000

150 x 300 = 45 000

mean = $\frac{6+9+5+8+0+10+2+1+8+11}{10}$

mean = 6

45000
+10 000
55000

55000 x 6 = 330000

Total number of dandelion plants = 3.3×10^5

Student S

0 4 . 2 Estimate the total number of dandelion plants in the field.

Calculate your answer using information from **Figure 5** and **Table 2**.

Give your answer in standard form.

[5 marks]

mean dandilion = 5 on field

Area of field = $300 \times 150 = 45000$ +

$= 100 \times 100 = 10000$

$55000 cm^2$

Area of quadrat = $1m \times 1m = 1m$

$55000 \times 1m^2 = 55000 cm^2$

Total number = $\frac{55000}{5} = 11000$

Total number of dandelion plants = 1.1×10^4

Example 2

Mark scheme

05.2	$3.0 \times 10^8 = 4.8 \times 10^9 \times \lambda$	an answer of 0.063 (m) scores **3** marks allow $\lambda = \frac{3.0 \times 10^8}{4.8 \times 10^9}$ this mark may be awarded if the standard form values are incorrectly converted	1	AO2 6.6.1.2
	$\lambda = 0.0625$ (m)		1	
	$\lambda = 0.063$ (m) **or** $\lambda = 6.3 \times 10^{-2}$ (m)	allow an answer to 2 sig figs that is consistent with their calculated value of λ and has required rounding	1	

Student T

0 5 . 2 The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

[3 marks]

3 ~~000000000~~ = 0.0625 metres

48 ~~000000000~~ = 0.06

Wavelength = 0.06 m

Student U

0 5 . 2 The radio waves have a frequency of 4.8×10^9 Hz

Wave speed of electromagnetic waves = 3.0×10^8 m/s

Calculate the wavelength of the radio waves.

Give your answer to 2 significant figures.

[3 marks]

3 ÷ 48 = .625

= 6.25 to 2S.F. is 6.3

Wavelength = _____ m

Example 3

Mark scheme

05.4		an answer of 2.24×10^{-3} scores **2** marks an answer of 0.00224 scores **1** mark		AO2 4.5.2.4
	$\frac{0.142}{63.5}$	allow an answer that rounds to 0.00224	1	
	$= 2.24 \times 10^{-3}$	allow an answer that rounds to 2.2×10^{-3}	1	

Table 4 shows the students' results.

Table 4

Current in amps	Mass of copper deposited on the negative electrode in grams
0.12	0.024
0.24	0.047
0.36	0.057
0.48	0.095
0.60	0.118
0.72	0.142

Student V

0 5 . 4 Calculate the number of moles of copper deposited on the negative electrode when the current is 0.72 A

Give your answer in standard form.

Use **Table 4**.

Relative atomic mass (A_r) of copper = 63.5

[2 marks]

$\frac{0.72}{63.5} = 0.0113385$

Number of moles = 1.13×10^{2}

Student W

0 5 . 4 Calculate the number of moles of copper deposited on the negative electrode when the current is 0.72 A

Give your answer in standard form.

Use **Table 4**.

Relative atomic mass (A_r) of copper = 63.5

[2 marks]

From table .72A is 0.142g ÷ 63.5
= 0.00224

Number of moles = 0.00224

Use an appropriate number of significant figures

General principles

- The ability to round to a correct number of significant figures is considered to be at least standard demand, so questions asking for significant figures may be on a Foundation paper.
- At low demand, we may ask for an answer to be given to a certain number of decimal places. We will give the prompt 'give your answer to x decimal places'.
- In questions where the prompt 'give your answer to x significant figures' (or 'give your answer to x decimal places') is seen, there is a mark for doing so.
- The number of significant figures required will follow the recommended practice of having the same number of significant figures as the lowest number in the data used (in preparation for work at A-level).
- If we don't ask for correct significant figures in a question, then the number of significant figures provided in the answer is generally inconsequential.
- However, if a student does decide to round their final answer and the rounding is incorrect, they might not get the final marking point.
- There may be a compensatory mark for an incorrect numerical answer quoted to correct number of significant figures – **but** only if the student has attempted a calculation using the data given. They would **not** gain that mark simply for quoting any correctly rounded number.
- Students should also be encouraged not to round in intermediate steps in a calculation, as this could result in their final answer being outside the acceptable range.
- Many students don't make an attempt at putting their answer to a required number of significant figures. So, to help students who miss or forget the instruction earlier in the question, from summer 2020 it will be repeated on the answer line to remind them. For example:

  Acceleration (2 significant figures) = _____

Progression of demand in assessment of significant figures

The table below shows how the features of GCSE Science assessment of use of significant figures progress from low to high demand.

How could you support your students operating at each of these levels of demand?

Low demand (Foundation tier only)	Standard demand (Foundation and Higher tier)	High demand (Higher tier only)
Significant figures **not** assessed at low demand, but students may be asked to give correct number of decimal places	Students will be expected to round down correctly	Students will be expected to round down correctly
		Students will also be expected to round up correctly

Example student responses

Example 4

Mark scheme

07.3	$\frac{(46 + 47 + 49)}{3}$ = 47 (cm^3) (2 sf)	an answer of 47 (cm^3) scores **2** marks allow 47.3(333) (cm^3) for **1** mark an answer of 43 (cm^3) scores **1** mark	1 1	AO2 4.6.1.1 4.6.1.2

Data table

Table 5

Time in seconds	**Volume of gas collected in cm^3**				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Mean**
0	0	0	0	0	0
40	46	30	47	49	**X**
80	78	83	83	82	82
120	98	94	96	95	96
160	100	100	100	100	100

Student X

0 7 . 3 Calculate mean value **X** in **Table 5.**

Do **not** include the anomalous result in your calculation.

Give your answer to 2 significant figures.

[2 marks]

46 + 47 + 49 = 142 ÷ 3 = 47.3

X = 47 cm^3

Student Y

0 7 . 3 Calculate mean value **X** in **Table 5.**

Do **not** include the anomalous result in your calculation.

Give your answer to 2 significant figures.

[2 marks]

46 + 30 + 47 + 49 = 172 ÷ 4 = 43

X = 43 cm^3

Student Z

0 7 . 3 Calculate mean value **X** in **Table 5.**

Do **not** include the anomalous result in your calculation.

Give your answer to 2 significant figures.

[2 marks]

46 + 47 + 49 = 142

142 ÷ 3 = 47.3

X = 47.3 cm^3

Example 5

Mark scheme

04.2	$\frac{780\,000 - 27\,000}{27\,000} \times 100$ $= 2788.\dot{8}$ = 2800 (%)	an answer of 2800 (%) scores **3** marks allow 2788.88889 (%) or correctly rounded answer for **2** marks allow an answer from an incorrect calculation correctly given to 2 significant figures	1 1 1	AO2 4.4.1.1

Data table

Scientists think that the Earth's early atmosphere may have been similar to the atmosphere on Mars today.

Look at **Table 4**.

Table 4

Gas	**Concentration of gas in the atmosphere today in parts per million**	
	Mars	**Earth**
Nitrogen	27 000	780 000
Oxygen	1 300	210 000
Argon	16 000	9 300
Carbon dioxide	950 000	400
Carbon monoxide	800	trace

Student AA

0 4 . 2 Calculate the percentage increase in nitrogen from the Earth's early atmosphere to the atmosphere today.

Assume the Earth's early atmosphere was the same as the atmosphere today on Mars.

Give your answer to 2 significant figures.

[3 marks]

$\frac{753000}{27000} \times 100 = 2788.888888$

To 2 sf = 2788.89

Percentage increase in nitrogen = 2788.9 %

Student BB

0 4 . 2 Calculate the percentage increase in nitrogen from the Earth's early atmosphere to the atmosphere today.

Assume the Earth's early atmosphere was the same as the atmosphere today on Mars.

Give your answer to 2 significant figures.

[3 marks]

% is 780 000 − 27 000 ÷ 780 000 × 100

= 96.538

Percentage increase in nitrogen = 97 %

Graphing skills

General points

- Students should be encouraged to use crosses when plotting data points rather than dots so that:
    - It's easier for the examiner to see that the plotting is accurate and within tolerance
    - the points will be clearly visible when the line of best fit is drawn (dots can disappear under a line and make it impossible to see whether the plotting has been accurate enough to gain the marks).
- There is usually a tolerance on plotting of plus or minus half a small square on the grid.
- We only ever ask students to plot a maximum of 6 points on a graph for 2 marks.
- To be credited with a single mark, students will need to plot 3/4 or 5/6 points correctly.
- If the data table includes 0,0 that point should also be plotted for full marks.
- The axis to be labelled will be indicated, except at high demand.
- Students should be encouraged to use the headings given in the table of data as a clue to what the label should be, and the data itself to decide on a suitable scale.
- We would expect a graph to cover at least half of the grid supplied. The grids in the paper are always drawn so that there is room to do this.
- We will indicate where we are expecting a line of best fit to be drawn, by the words 'draw a line of best fit'. Students should understand by this that we are expecting them to do something other than simply join the data points using straight lines and a ruler. See below for more information on drawing lines of best fit.
- From summer 2020, we include an instruction that makes it clear that students can use pencil for drawing (although pencil-drawn graphs have always been accepted).

Assessment principles

- The level of demand depends to a large extent on the complexity of the data to be processed.
- At all levels we may ask students to label or give a scale to one of the axes. There will be a prompt at lower demands as to which axis this should be; at higher demands students will be expected to understand what is needed.

At low demand:

- data points will be simple numbers (whole numbers or simple decimals)
- students will be asked to plot a single variable
- scales will be clear and straightforward
- numbers to be plotted will be on a straight line
- a line of best fit will be all points on a straight line
- we may ask students to extrapolate the line.

At standard demand:

- data points will be more complex numbers
- the scale may be more complex
- data may be on a straight line or a curve
- a line of best fit will be:
    - a straight line where points do not all sit on the line **or**
    - a straight line, with an anomaly that needs to be ignored **or**
    - a curve, where all points sit on the curve
- students may need to extrapolate from a curved line.

At higher demands:

- data points may include negative values
- may be a complex scale and/or multiple variables
- may be required to label and choose an appropriate scale for both axes

- a line of best fit will be:
    - a curve, where all the points do not sit on the line **or**
    - a curve, where there is an anomaly that must be identified and ignored without prompting
- students may need to extrapolate from a curved line.

Drawing lines of best fit

Whether students should draw a line of best fit or a dot-to-dot graph depends on the data that they are plotting.

For example, if students were plotting a table of patient's blood pressure measured at certain time periods, the assumption is that each value for blood pressure is the actual value for that particular time and we cannot tell what happens to the blood pressure between the data points. So we draw a line that passes through all the points – a dot-to-dot.

If, however, they were plotting data about the extension of a spring with mass added, the assumption is that there is a simple relationship between the two variables so that the true values all lie on the line and that if all the values could be measured accurately then they would lie in the line. In practice, because the measurements are not completely accurate we would draw a line of best fit.

As a rule of thumb, when drawing a line of best fit there should be as many points on one side of the line as the other. Often the line should pass through, or very close to, the majority of plotted points. A line of best fit should be continuous and drawn thinly so that it does not obscure the points below.

Students need to realise that an appropriate line of best fit is not necessarily a straight line through the origin as they may have been taught in their maths lessons. In science, it often is a curve because the underlying relationship in the data is non-linear.

The Association for Science Education has produced an excellent guide, *The Language of Mathematics in Science: A Guide for Teachers of 11-16 Science*, which explains very clearly examples of when a line of best fit is to be drawn or when a dot-to-dot would be accepted. You can download it free from ase.org.uk. On pages 29 and 30 of this guide, they give very clear examples of the type of line to draw.

The ASE guide also explains very clearly in Chapter 7 (specifically Section 7.7) about plotting lines of best fit in linear and non-linear relationships.

They also have a booklet of teaching approaches as a complement to this guide, which you may also find helpful.

In questions at all levels of demand, we will prompt students with the instruction 'Draw a line of best fit', which they should take as an indication that a line of best fit, and not a dot-to-dot drawing, is required.

Progression of demand in assessment of graphing skills

The table below shows how the features of GCSE science assessment of graphing skills progress from low to high demand.

How could you support your students operating at each of these levels of demand?

Low demand (Foundation tier only)	Standard demand (Foundation and Higher tier)	High demand (Higher tier only)
Scale or labels for one axis Axis to be completed will be indicated	Scale and/or label for one axis Axis to be completed will be indicated	Scale and label for one or both axes No prompting as to scale or labels
Simple numbers or simple decimals	More complex numbers	Complex numbers, including negative values
Single variable	Single variable	Multiple variables or scales
Clear, straightforward and simple scales	Scales will be more complex	Complex scales
Numbers to be plotted will fall on grid lines	Numbers may not all fall on grid lines	Numbers may not fall on grid lines
Numbers to plot will be on a straight line	Numbers to plot will be on a straight line **or** on a curve	Numbers to plot on a curve
Line of best fit will be a straight line with all points on the line	Line of best fit more demanding: a straight line where all points do not sit on the line **or** with an anomaly that needs to be ignored (with prompt), **or** a clear curve with all points on the curve	Line of best fit more demanding: a curve, where points do not all sit on the curve **or** where there is an anomaly that must be identified and ignored with no prompting
Students may be asked to extrapolate from a straight line	Students may be asked to extrapolate from a curve	Students may be asked to extrapolate from a curve

Example student responses

Example student Example 6

Mark scheme

11.3	both points plotted correctly correct line of best fit drawn	 to pass through (0,0) and (10,20)	1 1	AO2 4.5.3

Data table and question

1 1 . 3 Complete **Figure 15** by plotting the missing data from **Table 4.**

Draw the line of best fit.

Table 4 is repeated here to help you answer this question.

[2 marks]

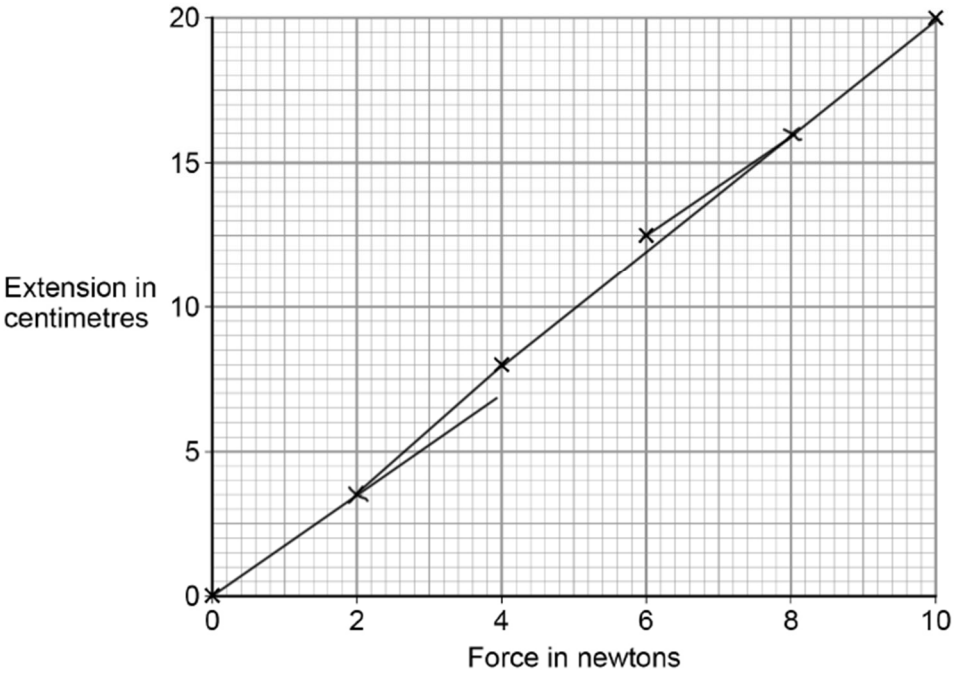
Table 4

Force in N	Extension in cm
0	0.0
2	3.5
4	8.0
6	12.5
8	16.0
10	20.0

Student CC

Figure 15 shows some of the data obtained by the student.

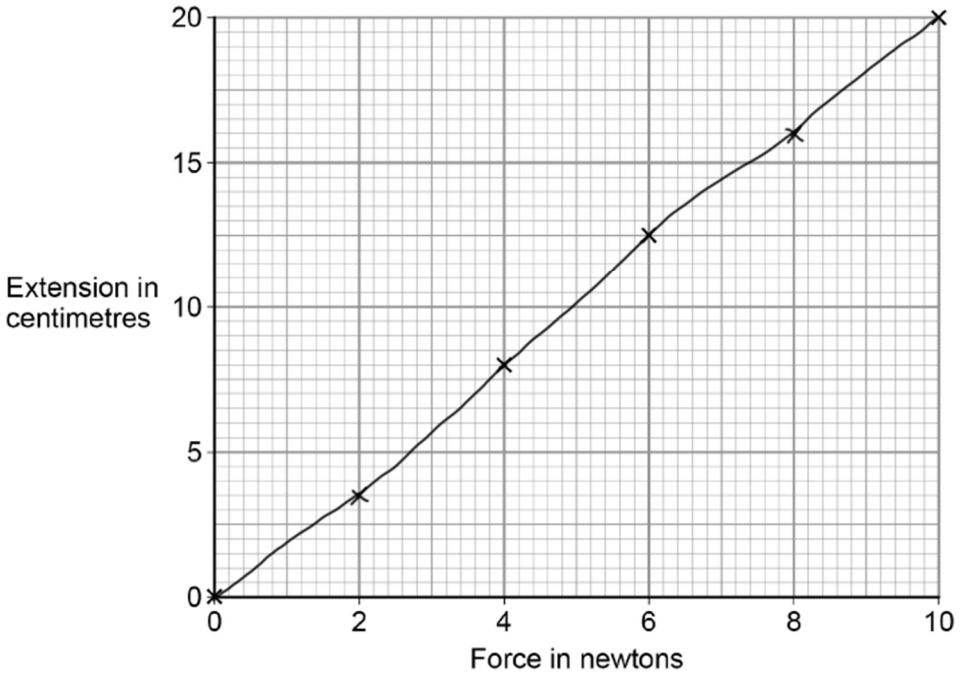
Figure 15



Student DD

Figure 15 shows some of the data obtained by the student.

Figure 15



Example 7

Mark scheme

02.5		(where a bar chart has been plotted) allow **1** mark for all bars plotted correctly if points are plotted as well as bars, ignore bars		AO2 4.4.1.2
	all points plotted correctly	allow ± ½ a square allow **1** mark for three points correctly plotted	2	
	smooth curve drawn through all points	ignore extensions of line / curve unless inconsistent with line / curve drawn	1	

Data table and question

Table 1 shows the student's results.

Table 1

Distance of light source from pondweed in cm	Number of bubbles produced in 30 seconds
5	40
10	13
15	5
20	2
25	1
30	0

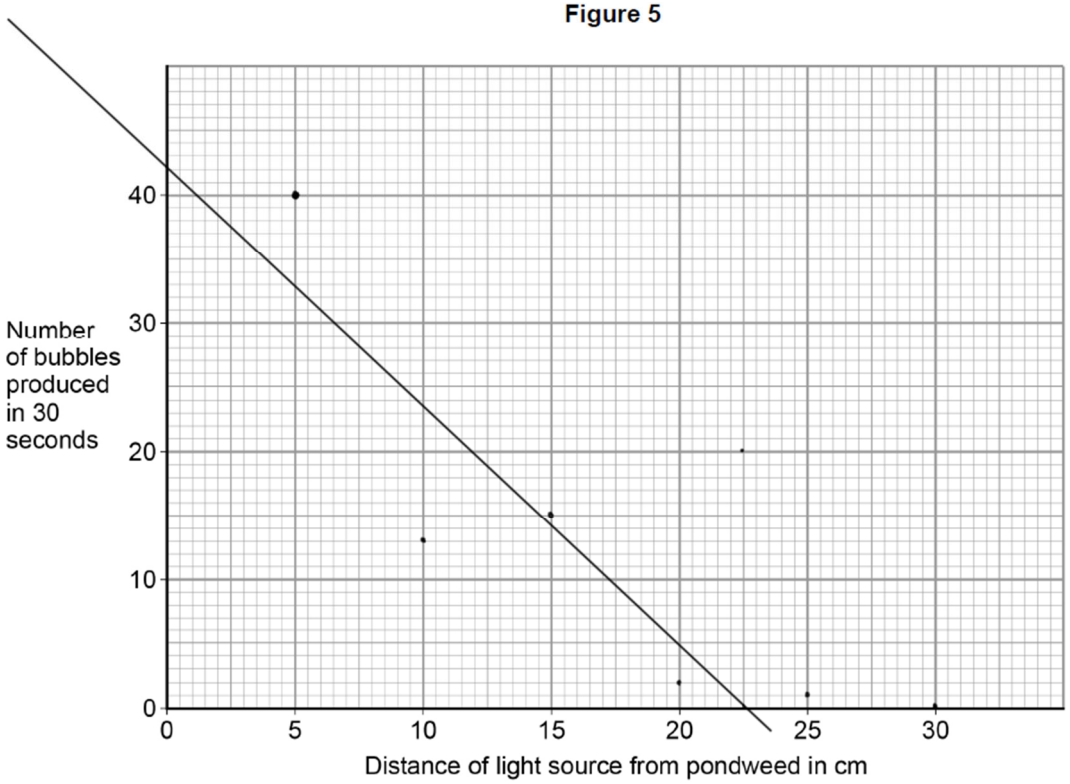
0 2 . 5 Plot the data from **Table 1** on **Figure 5**

Draw a line of best fit.

[3 marks]

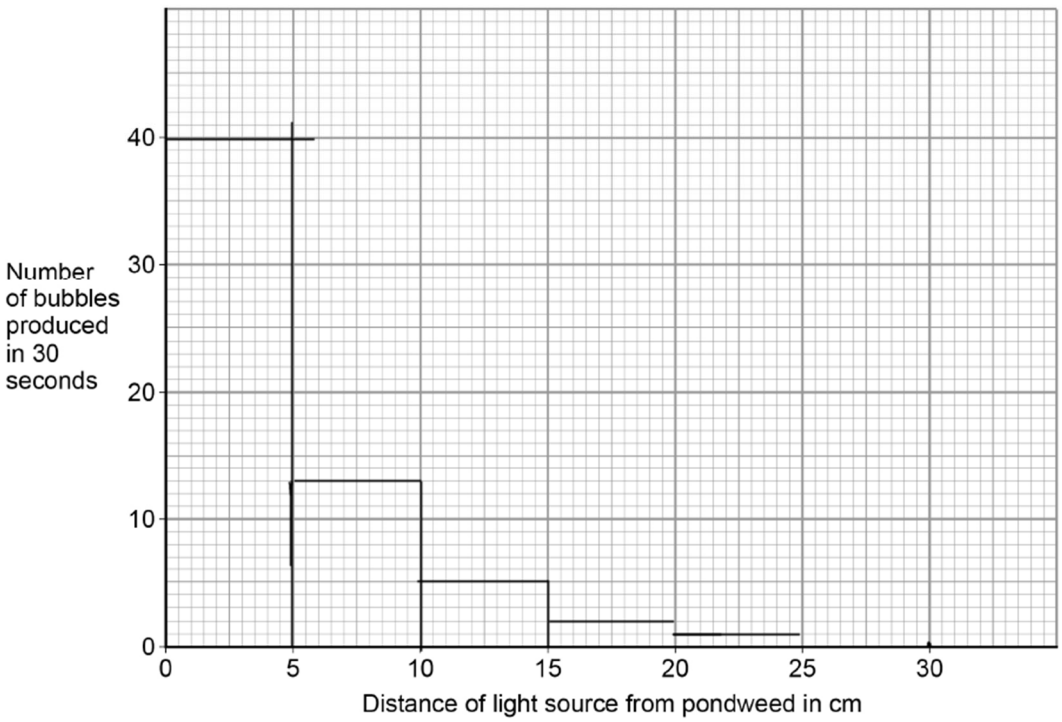
Student EE

Figure 5



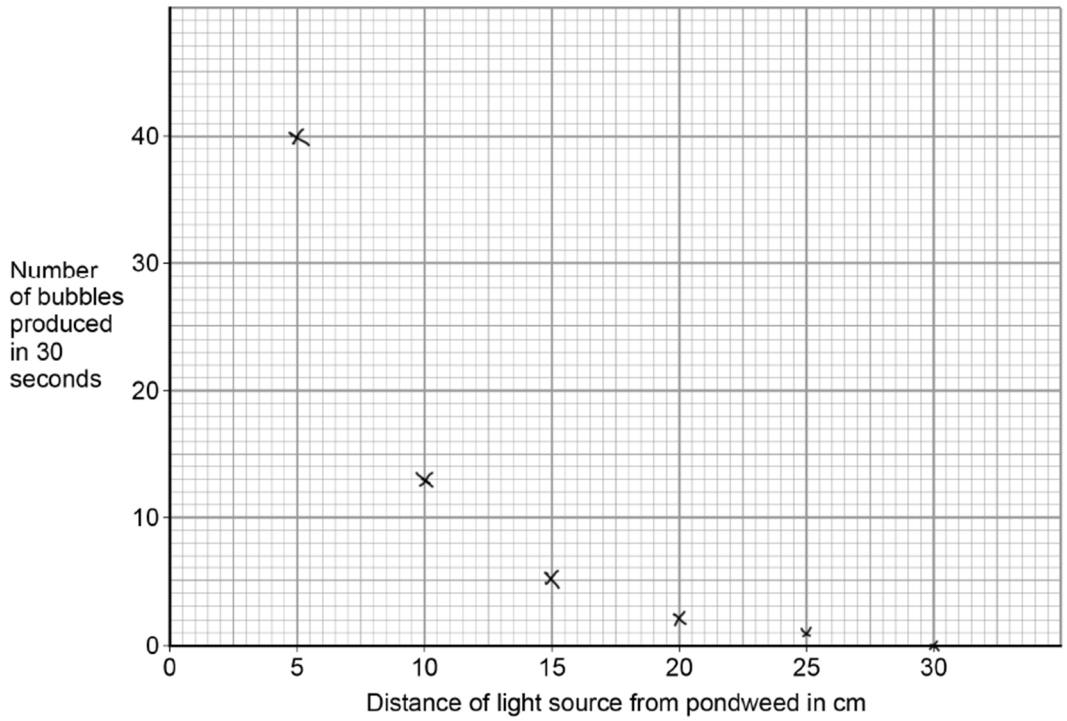
Student FF

Figure 5



Student GG

Figure 5



.

Example 8

Mark scheme

<table>
<tr>
<td>04.2</td>
<td>suitable scale and label for y-axis

all points plotted correctly

line of best fit</td>
<td>allow 5 or 6 per 2 cm

do not accept 5 per 1 cm

allow ± ½ a square
allow 1 mark for 4 correct points

<table>
<tr><th>conc. …</th><th>percentage (%) change…</th></tr>
<tr><td>0.0</td><td>+ 24</td></tr>
<tr><td>0.2</td><td>+ 12</td></tr>
<tr><td>0.4</td><td>+ 1</td></tr>
<tr><td>0.6</td><td>- 8</td></tr>
<tr><td>0.8</td><td>- 15</td></tr>
</table>
</td>
<td>1

2

1</td>
<td>AO2
4.1.3.2</td>
</tr>
</table>

Data table and question

Table 2 shows the results.

Table 2

Concentration of sugar solution in mol/dm^3	Percentage (%) change in mass
0.0	+24
0.2	+12
0.4	+1
0.6	–8
0.8	–15

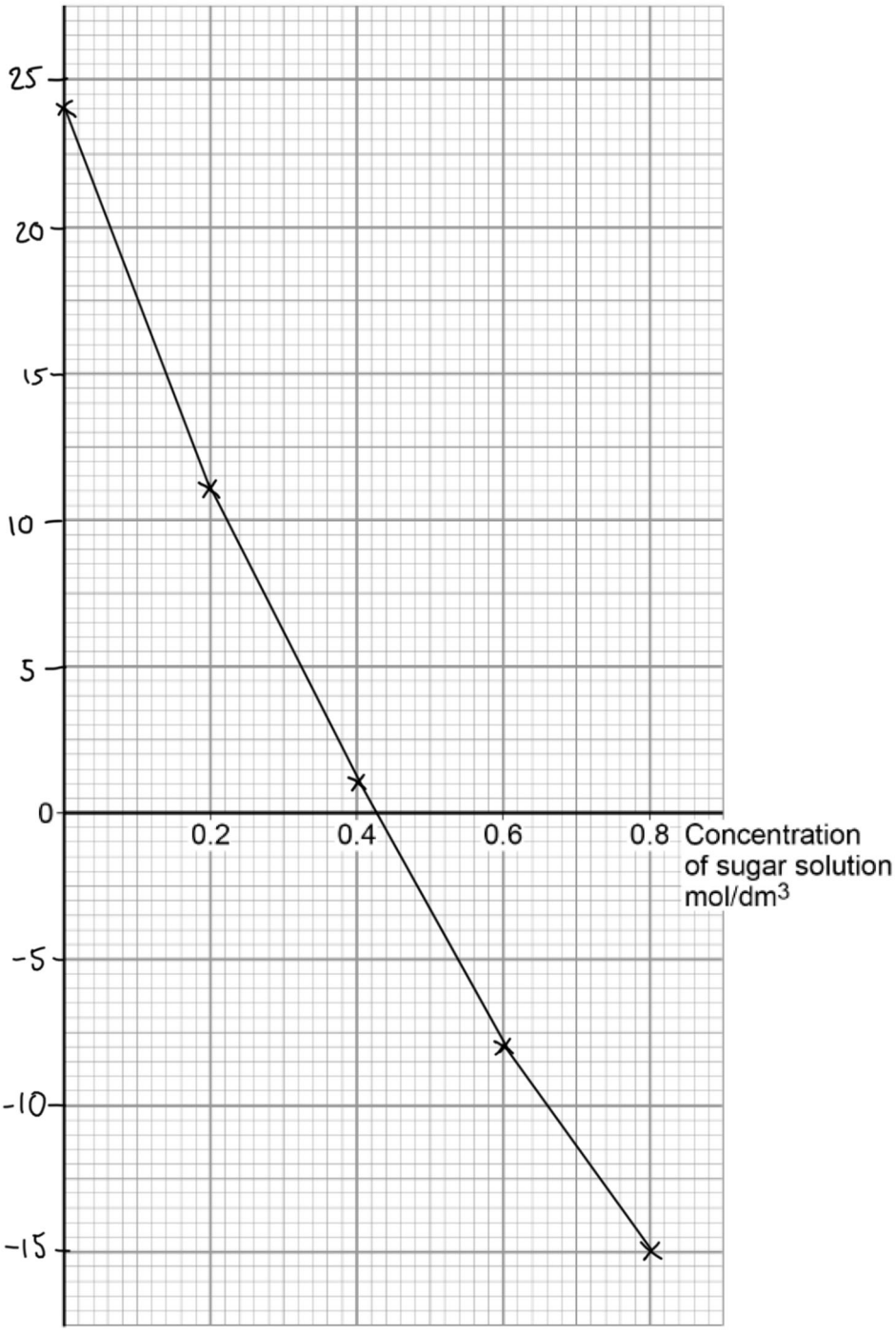
0 4 . 2 Complete **Figure 7** using the results in **Table 2**

- Choose a suitable scale and label for the y-axis.
- Plot the results.
- Draw a line of best fit.

[4 marks]

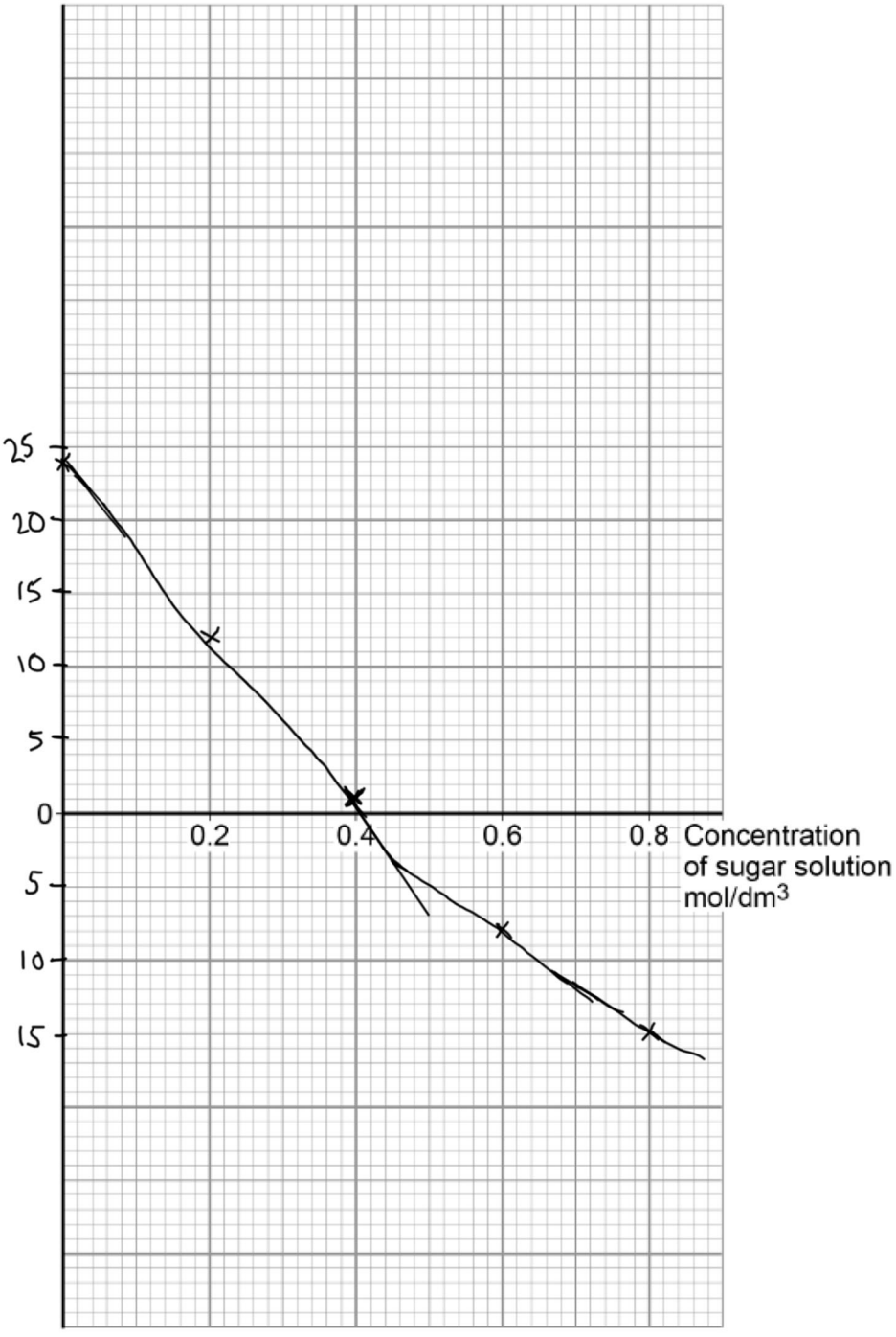
Student HH

Figure 7



Student II

Figure 7



Equations

General points

Physics equations

There are two lists of physics equations:

- 23 equations that students need to recall and be able to apply (21 in Combined Science). At low demand, students will be given the equation to apply; at standard demand, they will be prompted with the words 'write down the equation which links …' and the symbols to be used given in brackets. At higher demands, there will be no prompts.
- 12 further equations (7 in Combined Science) that will be provided on a sheet inserted into the exam papers, from which students must be able to select and apply the appropriate equation. At levels of demand below high demand, students will be prompted by the words 'Use the physics equations sheet'.

Chemistry equations

In chemistry, students need to be able to recall and apply the following equations:

- calculation of R_f
- calculation of mean rate of reaction
- calculation of percentage yield (separate chemistry only)

Biology equation

In biology, there is only one equation that students need to be able to recall and apply: the magnification equation.

Progression of demand in assessment of equation skills

Equations are assessed in different ways, depending on the level of demand and the Assessment Objective targeted (AO1 or AO2). See table below.

Low demand (Foundation tier only)	Standard demand (Foundation and Higher tier)	High demand (Higher tier only)
AO1 Equation recall assessed usually by multiple choice or link boxes.	AO1 Students will be given the prompt 'Write down the equation which links…' The terms are written in alphabetical order, and the symbols to use given in brackets after the term.	AO1 Simple recall of equations not assessed at higher demand. There are no marks simply for writing an equation down: students will need to do something with the equation. No prompt given about which equation to use. Questions will involve transformations or 'something extra'.
AO2 Students will be given the equation(s) to apply. Will involve substitution of two numbers, no transformations. May involve unit conversion.	AO2 Calculation will involve something 'extra' eg simple transformation, unit conversion.	AO2 There will be no prompts as to the equation to use. Tasks will include complex equations, transformations and multiple steps.

Example student responses

Example 9

Mark scheme

03.2		an answer of 833 (N) **or** 830 (N) scores **2** marks		AO2 6.5.1.3
	weight = 85 × 9.8		1	
	weight = 833 (N)	allow weight = 830 (N)	1	

Student JJ

0 3 . 2 The man has a mass of 85 kg

Gravitational field strength = 9.8 N/kg

Calculate the weight of the man.

Use the equation:

weight = mass × gravitational field strength

[2 marks]

85 x 9.8 = 841.5

Weight = 841.5 N

Student KK

0 3 . 2 The man has a mass of 85 kg

Gravitational field strength = 9.8 N/kg

Calculate the weight of the man.

Use the equation:

weight = mass × gravitational field strength

[2 marks]

85 ÷ 9.8 = 8.673

Weight = 8.63 N

Student LL

0 3 . 2 The man has a mass of 85 kg

Gravitational field strength = 9.8 N/kg

Calculate the weight of the man.

Use the equation:

weight = mass × gravitational field strength

[2 marks]

85 x 1000

85000 x 9.8 = 833000

Weight = 833000 N

Student MM

0 3 . 2 The man has a mass of 85 kg

Gravitational field strength = 9.8 N/kg

Calculate the weight of the man.

Use the equation:

weight = mass × gravitational field strength

[2 marks]

Weight = 8,330 N

Example 10

Mark scheme

06.4	(resultant) force = mass × acceleration	allow F = m a	1	AO1 4.5.6.2.2
06.5	4.0 = 2.5 × a $a = \frac{4.0}{2.5}$ a = 1.6 (m/s^2)	an answer of 1.6 scores **3** marks	1 1 1	AO2 4.5.6.2.2

Student NN

0 6 . 4 Write down the equation which links acceleration, mass and resultant force.

[1 mark]

acceleration = mass x resultant force

Student OO

0 6 . 4 Write down the equation which links acceleration, mass and resultant force.

[1 mark]

Acceleration = mass / resultant force

Student PP

0 6 . 4 Write down the equation which links acceleration, mass and resultant force.

[1 mark]

mass = resultant force x acceleration

Student QQ

0 6 . 5 A rope is used to pull the lifebuoy to the side of the swimming pool.

A resultant force of 4.0 N acts on the lifebuoy.

The mass of the lifebuoy is 2.5 kg.

Calculate the acceleration of the lifebuoy.

[3 marks]

4 = 2.5 x acceleration

2.5 ÷ 4 = 0.625

Acceleration = 0.625 m/s^2

Student response RR

0 6 . 5 A rope is used to pull the lifebuoy to the side of the swimming pool.

A resultant force of 4.0 N acts on the lifebuoy.

The mass of the lifebuoy is 2.5 kg.

Calculate the acceleration of the lifebuoy.

[3 marks]

Acceleration = 4 x 2.5

Acceleration = 10

Acceleration = 10 m/s^2

Example 11

Mark scheme

09.3		an answer of 0.12 (kg) **or** an answer that rounds to 0.12 (kg) scores **5** marks		AO2 4.2.4.2 4.1.1.3
	E = 2530 × 14	this mark may be awarded if P is incorrectly / not converted	1	
	E = 35 420 (J)	this answer only	1	
	35 420 = m × 4200 × 70	allow their calculated E = m × 4200 × 70	1	
	$m = \frac{35\,420}{4200 \times 70}$	allow $m = \frac{\text{their calculated E}}{4200 \times 70}$	1	
	m = 0.12 (kg)	allow an answer that is consistent with their calculated value of E	1	

Student SS

0 9 . 3 The coffee machine heats water from 20 °C to 90 °C.

The power output of the coffee machine is 2.53 kW.

The specific heat capacity of water is 4200 J/kg °C.

Calculate the mass of water that the coffee machine can heat in 14 seconds.

[5 marks]

Change in thermal energy = mass x 4200 x 70°C

90 - 20 = 70°C

power = energy transferred / time

2·53 x 1000 = 2530

power x time = energy transferred

2530 x 14 = 35420

Mass = _____ kg

Student TT

0 9 . 3 The coffee machine heats water from 20 °C to 90 °C.

70°C Δt

The power output of the coffee machine is 2.53 kW.

The specific heat capacity of water is 4200 J/kg °C.

Calculate the mass of water that the coffee machine can heat in 14 seconds.

[5 marks]

$\Delta E = mc\Delta\theta$

$2.53kw = m \times 4200 \times 70°C$

$m = \frac{(4200 \times 70)}{2.53}$ $\quad m = \frac{2.53}{(4200 \times 70)} \times 14.$

$= 1.204761905 \times 10^{-4}$

Mass = 1.2×10^{-4} kg

Student UU

0 9 . 3 The coffee machine heats water from 20 °C to 90 °C.

The power output of the coffee machine is 2.53 kW. 2530w 35420J

The specific heat capacity of water is 4200 J/kg °C.

Calculate the mass of water that the coffee machine can heat in 14 seconds.

[5 marks]

$P = \frac{\text{energy}}{\text{time}}$ $\quad 90 - 20 = 70$

$2530 \times 14 = 35420$

$35420 = m \times 4200 \times 70$

$\frac{35420}{4200 \times 70} = m$

$m = 0.12047619kg$

Mass = 0.12 kg

Appendix

Activity 3: Diagnostic question examples

Many maths question target a number of skill areas. In the table below we have listed some of the question from 2018 which assess each maths skill. This may make your search in *Exampro* for the editable word versions easier. The ones highlighted in blue may be particularly good examples to edit and use as diagnostic questions.

Maths skill	Paper/question number	Question details
1a	Chemistry 1F Q3.2	Calculate RAM using a formula and answers given to 1dp.
1b	Chemistry 1F Q3.4	Calculate the radius of an atom and give answer in standard form.
	Synergy 4F Q2.8	Using numbers expressed in standard from
	Synergy 1H Q9.1	Recognise order of size when expressed in standard form.
	Synergy 3H Q6.5	Calculate the number of copper ions in the solution using the Avogadro constant and express answer in standard form.
	Synergy 4H Q5.4	Calculate the number of moles give answer in standard form.
1c Ratio	Synergy 3F Q1.8	Simplifying ratios
	Trilogy Chemistry 2F Q6.5	Balance the equation
	Chemistry 2F Q4.3	**Calculate a mass using ratios**
	Biology 2F Q4.7	Calculate ratio from Punnett square
	Trilogy Chemistry 1F Q5.5	Calculate mass of solid copper chloride
	Chemistry 1F Q2.5	Calculating RAM
1c Fractions	Biology 1F Q1.5	Pie chart and fractions
1c Percentage	Chemistry 1F Q1.4	Calculate simple percentage taking numbers from diagram
	Synergy 4F Q9.5	Calculation from simple percentage
	Trilogy Chemistry 2F Q4.7	Multiple choice: Identifying the calculation to work out a percentage
	Synergy 1F Q3.3	Using a simple percentage to calculate mass of oxygen
	Chemistry 1F Q2.6	Calculate percentage yield
	Chemistry 1F Q 9.5	Calculate percentage atom economy plus sig fig
	Chemistry 2F Q1.4 and 1.5	Calculate simple percentage linked to 1.4
	Chemistry 2F Q9.2	Calculate percent by mass
	Synergy 2F Q2.3 and 2.4	Simple percentage calculations using pie chart and fractions
	Biology 2F Q1.2	Simple percentage calculation. Biology content only.
	Biology 1F Q8.3	**Percentage decrease, formula given and sig fig**
	Trilogy Biology 1H Q5.2	**Percentage decrease, formula not given**
	Synergy 2H Q6.1	Percentage decrease, formula not given
	Biology 1F Q8.6	**Using a graph to work out change plus plotting graph**

	Biology 1H Q4.2 Trilogy Physics 1F Q6.3	**Calculate percentage change from table of results formula not given** Calculate simple percentage
1d	Trilogy Chemistry 1F Q5.3 Chemistry 1H Q4.5	Find the missing value (Estimate) Estimate a value MC uses skill 3a
2a assessed with other calculations; 2c and 2f go together; 2c and 4a often assessed together **2c,2g,2h and all skill 4 could be put together**		
2a	Trilogy Chemistry 2H Q4.2 Synergy 1F Q8.5 Synergy 1H Q8.5	Calculate number of moles and give answer to 2 sig fig Using Rf equation and give answer to 2 sig fig paired with H tier question for good differentiation
2b	Synergy 4F Q6.6 Trilogy Chemistry 2F Q3.2 Chemistry 2F Q7.3 Biology 2F Q6.4 Q6.5	Simple mean using decimals Simple mean using decimals plus answer to 2 sig fig Calculate simple mean plus sig fig Calculate simple mean plus calculate percentage decrease (formula given)
2c	Trilogy Chemistry 2F Q4.8 Synergy 4F Q1.6	Interpreting a simple bar chart Plotting a simple bar chart
2d	**Biology 1F Q8.7**	**Factors to consider when selecting two populations to compare effect of smoking (see example diagnostic question)**
2e	Biology 2F Q4.7 Trilogy Biology 2F Q5.5	Simple expression of ratio Probability using a Punnett square
2f	Biology 2H Q8.1	Understanding term modal
2g	Biology 2F Q5.6	Scatter diagram, understanding term correlation
2h	Trilogy Biology 1F Q4.1 Trilogy Biology 1H Q 3.5	Comparing pattern of results on a bar chart Relation of light intensity and distance (doubling)
3c 3d assessed in same physics questions; for any physics equation above LD, 3b can be part of 3c		
3a	Assessed in 3b, 3c and 3d.	
3b	Chemistry 1H Q8.8	Calculate mass when percentage yield is given
3c	**Trilogy Biology 1F Q6.5** **Synergy 1F Q 4.7** **Synergy 1H Q6.2** Trilogy Chemistry 2F Q5.4 Synergy 3F Q5.1 Chemistry 2F Q5.4 Trilogy Physics 2F Q3.5 Trilogy Physics 2FQ 5.5 Q5.6	**Calculate magnification plus unit conversion** **Calculate magnification paired with H tier question for good differentiation** Calculate mean rate of reaction, formula given Calculate mean rate of reaction using values read from graph, formula given Calculate Rf value, formula given Calculate resultant force, formula given

	Trilogy Physics 2H Q3.1 Q3.2 **Synergy 3H Q3** Trilogy Physics 2H Q4.3	Recall extension of spring equation and calculate force **Recall momentum equation , rearrange to find mass** **Whole question links idea of transmission efficiency and power using equations** Calculate extension of spring (multi step)
3d	Any Biology or Physics equation question	
4a and 4c assessed together		
4a	Chemistry 1F Q 6.3 Physics 1H Q 4.4	Add bar to simple bar chart, whole number Take readings off graph and use them to workout percentage increase
4b	Not assessed in 2018	
4c	Synergy 4F Q3.1 Trilogy Chemistry F2 Q5.6 Trilogy Physics 2F Q7.5 Biology 1F Q8.5 **Synergy 1F Q10.1**	Plot and line of best fit Plot and line of best fit values in decimals, 0.0 plot Plot and draw line of best fit ,values in decimals Add scale, label axis and complete line of best fit **Choose scale, label axis, plot points and complete line of best fit**
4d	Trilogy Chemistry F1 Q4.7 Trilogy Chemistry H1 Q6.3 **Synergy 1F Q10.2**	Identify mistakes and then calculate correct gradient, formula given. Calculate gradient of line and give the unit **Determine the gradient from graph plotted in 10.1**
4e	Trilogy Chemistry 2H Q5.2 and 5.3 **Synergy 3H Q8.4**	Describing a trend, explain how you would find the rate of a reaction by drawing a tangent to a curve – could modify question to include calculating the rate **Determine the acceleration using a curved velocity time graph (whole question covers 4a,4c,5c)**
4f	Not assessed in 2018	
5a	Synergy 4F Q 6.1	Measure an angle
5b	Trilogy Chemistry 2F Q6.3 Chemistry 2F Q9.6 Synergy 4F Q9.1 Chemistry 1H Q7.4 Physics 2H Q6.4	Name alkane from a picture of moly mod Complete display formula Complete the structure of poly(ethene) Calculate bond energies from display formula energies given Draw a vector diagram
5c	Chemistry 1F Q1.7 Trilogy Chemistry 2H Q5.7 **Biology 2H Q4.2** Synergy 1H Q9.2	Calculate volume (multi choice) Calculate SA of cube volume given **Calculating areas plus standard form and calculating means** Explain the relationship of SA:Vol changes as cells size increases

Activity 5: Commentaries and marks

Biology 2H 2018 Q7.2

Examiner report

07.2 There were two possible routes for the calculation of the percentage of biomass lost between the algae and the large fish, given that their biomasses were 840 and 10 g/m^2 respectively.

Allowance was made for arithmetic errors in that one mark was available for an answer given to two significant figures, correctly derived from an incorrect answer to the calculation. Many students did not give their answer correct to two significant figures eg '98.8' was a common answer. This scored two of the three marks available, provided it was evident that an appropriate method had been used to produce this figure. 51% of students achieved full marks, with a further 13% achieving two marks.

Script A

This student gains one mark for MP3. Although their answer is incorrect, the have attempted a calculation using figures from the question annd they have given their incorrect value correctly to 2 significant figures. Note that writing down any values and then giving this to the correct number of significant figures would not gain the mark. The values used in the calculation have to link to the values used in the question.

Total for Script A: 1 mark

Script B

This student gains 3 marks. They've used a different approach to the calculation but it is correct and rounding is also correct.

Total for Script B: 3 marks

Trilogy Chemistry 1H 2018 Q8.3

Examiner report

08.3 Students found this question tough, but it discriminated well with higher-attaining students being able to achieve four or five marks (10%). 74% of students scored zero marks.

The most common mistake found in correct calculation methods was the absence of a conversion from g to mg. Some got to 0.185 g and then stopped or converted g to mg incorrectly. Common errors were dividing by 1000 rather than multiplying by 1000 or using a factor of 10 or 100 to convert g to mg.

Stoichiometry was not well understood which resulted in students obtaining an answers of:

- 280 mg or 0.280 g due to the omission of the stoichiometric ratio (× 2/3) or
- 124 mg or 0.124 g where they had divided by 72 and multiplied by 112, and had multiplied by 2/3 as well, so they had taken the ratio into account twice.

Some students got as far as 0.12/24 or 0.12/72 and then no further. Others tried to calculate RFMs for the compounds involved and got no further and gained no marks.

Script C

This is within the range 0.185–0.19, but no conversion was attempted so MP5 was not obtained.
Total for Script C: 4 marks

Script D

Method 1 has been used for MP1. There is no indication of what figures relate to. No further steps have been undertaken.
Total for Script D: 1 mark

Script E

Method 2 has been used for MP1 and 2. The method is clearly set out for the steps the student took, but no further steps were shown beyond MP2.
Total for Script E: 2 marks

Synergy 4H 2018 Q7.3

Examiner report

07.3 Around 3% of students performed this complex calculation correctly to gain all six marks. Some students attempted calculations, but it was often difficult to follow the line of reasoning. Strings of figures, apparently randomly multiplied or divided, were often seen, with no attempt to explain what was being worked out. It would benefit students to explain, just with a word or two, what they think they are working out. Some students attempted to deal with all stages of this multi-stage calculation in one equation – such answers seldom scored any marks.

Of those whose working was clear enough to follow, the most frequent mistake was working out the input power as 72% of the output power, ending up with a smaller value for the input power than the output. However, such answers could go on to gain up to three of the marks by using the P = IV equation and/or multiplying by four.

Script F

The student wrote down the equations he/she could recall that included power or potential difference and then seleccted the correct one to use. The response was set out slightly differently from that in the mark scheme, as they factored in the four motors at the beginning of the calculation, rather than at the end. Any correct method will always gain credit. The final answer was correct and the response gained 6 marks. The answer in the mark scheme is given as 29A, as the figures in the question are given to 2 significant figures. The final answer should match this, although students are not penalised unless they are asked to give their answer to a certain number of significant figures.
Total for Script F: 6 marks

Script G

This response gained 1 mark. The student realised there were four batteries and correctly calculated the total power output. None of the other steps in the calculation were correct.
Total for Script G: 1 mark

Script H

This response gained 1 mark for realising there were four batteries, as shown on the second line. The student used an incorrect value for the total power output, but correctly multiplied this value by four.
On the bottom three lines, the student gave three different versions for the follow on calculation that was required. The answer on the line shows that the student selected an incorrect calculation, so could not gain credit. If the student had selected the first of these three calculations, they could have gained a further 2 marks, giving a total of three.
Total for Script H: 1 mark

Chemistry 2H 2018 Q8.3

Examiner report

08.3 A significant number of students did not draw a tangent at 0.95 g but used 0.95 g to calculate the **mean** rate over the first 0.95 g lost. Such students were able to score the third and fourth marking points. A small number of students drew the tangent in the wrong place choosing the other number (50) quoted in the question.

Some students had difficulty with the scales on the graph either by:

- forgetting that the *y*-axis intervals were 0.1 and calculating the difference as a whole number rather than the actual difference eg 18 rather than 0.18
- counting the number of squares on the *y*-axis or the *x*-axis eg 1.00 − 0.8 = 10 (squares) rather than 0.2

Many students were able to state that the gradient of the tangent is calculated by the *y* value divided by the *x* value and calculate a value correctly. But some students neglected to quote their answer to two significant figures. 25% of students achieved full marks.

Script I

The tangent is drawn correctly and the value for Y and X are correctly read and substituted into the equation, so the first 3 MP are given. The student didn't round this answer to 2 significant figures so the final MP was not awarded.
Total for Script I: 3 marks

Script J

The tangent is correctly drawn at 0.95g so MP1 was given.
The X and Y value are not indicated correctly on the graph or in the answer. There are two calculations and the correct evaluation is not indicated. The answer on the answer line 0.375 is not to 2 significant figures.
Total for Script J: 1 mark

Script K

MP1, 2 and 3 were awarded, but the answer is not quoted to 2 significant figures, so MP4 was not awarded.
Total for Script K: 3 mark

Script L

MP1, 2 and 3 were awarded, but the answer is not quoted to 2 significant figures, so MP4 was not awarded.
Total for Script L: 3 mark

Trilogy Biology 1F 2018 Q6.5 (1H Q1.5)

Examiner report

06.5 There were three marks available for this question.

- The first mark was for conversion of units. Many students did not attempt a conversion but could still go on to achieve two marks. A range of different errors were made which included multiplying or dividing by 10, 100 or 10 000, rather than by 1000. Some did not appreciate that a micrometre is smaller than a millimetre.
- The second mark was for correctly substituting into the rearranged equation to calculate magnification. This mark was allowed even if their initial conversion was incorrect.
- The final mark was for an answer of 400. Some students added a unit to their answer and this negated the mark.

22% of students achieved two marks. 56% of students scored zero marks. This was often for 280 ÷ 112 = 2.5

Script M

MP1 is not awarded as the unit conversion is incorrect. However, MP2 is awarded as the student substitutes their incorrect value correctly into the equation. MP3 is also awarded as this is the correct value for the correct calculation completed using incorrect values.
Note that, if this student had not gained any marks for the maths, one mark is available for the equation but the triangle with only letters at the top is insufficient for this.
Total for Script M: 2 marks

Script N

The equation at the top would have gained a mark if no other calculation marks were awarded. MP2 is awarded for the student using the correct equation but with the incorrect values. MP1 hasn't been awarded as the values haven't been converted. MP3 would have been awarded for a correct value for the given equation but the student has given incorrect units which negate the mark.
Total for Script N: 1 mark

Trilogy Physics 2H 2018 Q5.2

Examiner report

05.2 25% gained full marks, and a further 18% gained two marks, usually not giving the answer to two significant figures. There were a large number of responses using an incorrect rearrangement of the equation and generally the use of standard form was not the cause of the errors.

Script O

The student tries to use an equation triangle, but the initial equation is incorrect, so the substitution does not score. There is no rounding necessary to get to 2 significant figures so there is no compensation mark.
Total for Script O: 0 marks

Trilogy Physics 2F 2018 Q5.5/Q5.6

Examiner report

05.5 24% of the students correctly recalled this equation. Many quoted the equation for elastic potential energy having referred to the Physics Equations Sheet.

05.6 Of those that gave the correct equation, most failed to convert the centimetres to metres. Only 2% gained three marks with a further 30% scoring two marks.

Script P

For question 5.5, the equation given is incorrect, scoring zero. For 5.6, the student doesn't convert the extension to metres so doesn't score the first marking point. Despite the previous incorrect equation, the student then uses the correct equation so the substitution is correct. The final answer is correct for the student's numbers, so MP 2 and 3 are awarded.

Total for Script P: 2 marks

Physics 2H 2018 Q2.5

Examiner report

02.5 For those students who correctly recalled the equation in question 02.4, most scored at least 3 marks here. About 35% converted centimetres to metres to score all 4 marks.

Script Q

The student needed to convert centimetres into metres so the final MP is not given. However, even though they totalled all the values for force and extension, which wasn't necessary, their calculation is correct, as they have substituted and rearranged correctly. As stated in the mark scheme, an answer of 0.5 scores 3 marks.

Total for Script Q: 3 marks

Activity 6: Commentaries and marks awarded

Example 1: Biology 2H question 4.2

This is a mixed-demand question. The calculation itself is considered high demand, as students need to:

- use the information and the data in the table to work out the mean number of plants per m^2 in the samples
- calculate the total area of the field
- use the values calculated to work out the mean number of plants for that area.

The presentation of the calculated value in correct standard form is standard demand for the following reasons:

- there are no numbers given in standard form to do the calculation with – we are just asking to convert the answer to standard form
- the answer is a positive index.

The mark scheme shows that if a student fails to correctly calculate the mean number of plants and/or the total field area, they can still gain compensation points for using their incorrect values correctly and giving their incorrect answer correctly in standard form.

Student R

The student has calculated the mean correctly as 6 (MP1). The area of the field is correct and the working can be seen (MP2). The student then correctly multiplies the mean by the area (MP3) to give the correct value of 330 000 (MP4). Finally, the student correctly gives this in standard form (MP5). It is fairly clear what the student has done here, but it could be clearer so that if a mistake had been made it would be easier to award working out marks.

Total for Student R: 5 marks

Student S

Compared to that of student A, this answer is well laid out, so you can follow the steps in the student's working out. Alas, the mean is incorrectly calculated so MP1 is not awarded. Whilst the value of 55 000 has been correctly calculated, the student has added incorrect units (cm^2 rather than m^2), so MP2 cannot be awarded. The student has next carried out an unnecessary calculation, multiplying their value for area by the area of the quadrat, which is not creditworthy. They have then divided their figure from this calculation by their mean, rather than multiplying it, so MP3 cannot be awarded, and the answer given is incorrect (1.1000), so MP4 cannot be awarded either. The standard form is incorrect for their answer value so MP5 also cannot be awarded. Therefore, this student gains no marks.

Total for Student S: 0 marks

Example 2: Trilogy Physics 2H question 5.2

In this high-demand question, students are expected to be able to use numbers given in standard form to carry out the calculation, although they are not required to give the answer in standard form. This question also assesses the ability to round to the correct number of significant figures at high demand. Although students are not required to give their answer in standard form, if they choose to do so the standard form must be correct to gain the final mark.

Student T

The student has laid their working out clearly. They have correctly carried out the calculation, having converted the numbers in standard form and cancelled out, to get the correct answer (MP1 and MP2). However, they have not quoted their final answer to the correct number of significant figures so do not gain the final mark.

Total for Student T: 2 marks

Student U

This student has attempted to calculate the answer, but in the attempt has multiplied by 10 instead of dividing it to get the answer so does not gain the first two marking points. However, their final answer is consistent with their calculated answer, correctly rounded to 2 significant figures so gains the compensation mark.

Total for Student U: 1 mark

Example 3: Synergy Paper 4H question 5.4

To answer this question students needed to read the correct value from the table and divide it by the relative atomic mass to give the number of moles of copper deposited. The requirement to give the answer in standard form is considered higher demand here, as the answer involves using a negative index.

Student V

The student has used the wrong value to carry out the calculation (0.72 A rather than reading the value from the table as instructed) so their answer is incorrect. They have attempted to convert their answer to standard form, but have done so incorrectly. No marks are gained for this response.

Total for Student V: 0 marks

Student W

This student has carried out the calculation correctly, but has not converted their answer to standard form as instructed so does not gain the second mark.

Total for Student W: 1 mark

Example 4: Chemistry 2F question 7.3

This is a mixed demand question. The calculation itself is low demand, a simple calculation of a mean ignoring the anomalous result. Rounding the answer to two significant figures involves rounding down, making the mark for significant figures standard demand. Students were allowed a compensation mark if they included the anomalous result to get an answer of 43.

Student X

This student has carried out the calculation correctly, and rounded to the required number of significant figures.

Total for Student X: 2 marks

Student Y

This student has calculated the mean for all four values and given their answer to the correct number of significant figures, and so gains the compensation mark.

Total for Student Y: 1 mark

Student Z

The student has done the calculation correctly but not given their answer to 2 significant figures, so does not get the second mark.

Total for Student Z: 1 mark

Example 5: Trilogy Physics 1H question 5.5

Overall this is a very high-demand calculation, requiring the calculated answer to be rounded up to give the final answer to the required number of significant figures.

Student AA

The student has carried out the calculation correctly, but has rounded to 2 decimal places rather than significant figures so does not get the final mark.

Total for Student AA: 2 marks

Student BB

The student has carried out the calculation incorrectly. However, they have correctly quoted their incorrect value to the correct number of significant figures so gain the compensation mark.

Total for Student BB: 1 mark

Example 6: Physics 2F question 11.3

The question is a mixture of low- and standard-demand marks.

- The numbers on the *x*-axis are all simple whole numbers and the data points fall on major grid lines.
- The data points for the y-axis are simple decimals, but the scale on the *y*-axis is slightly more complex (2 small squares for 1 cm extension).
- Although four points have already been plotted, as a prompt to using the scale, the plotting is considered to be just standard demand.
- The line of best fit is a straight line, with all points sitting on the line.

Student CC

The points are plotted correctly, scoring MP1, but the line of best fit is poor, so the second mark is not awarded

Total for Student CC: 1 mark

Student DD

The student hasn't plotted the points and has tried to draw a line of best fit without using a ruler.

Total for Student DD: 0 marks

Example 7: Trilogy Biology 1F question 2.5

This question is a mixture of low and standard demand.

The plotting of the points is low demand for the following reasons:

- all the data points are simple whole numbers
- on the *x*-axis all points will sit on major grid lines
- on the *y*-axis all points sit on smaller but still clear grid lines.

The line of best fit is a smooth curve with all points sitting on the line, so this is standard demand.

It is important that students understand that the lines of best fit will not necessarily be a straight line.

Student EE

The student has plotted five points within the tolerance allowed, but has incorrectly plotted the number of bubbles at a distance of 15 cm, so is awarded only 1 mark out of 2 for the plotting. The student has then made the error of drawing a straight line rather than looking at the pattern of the data and drawing a smooth curve, so does not gain the mark for the line of best fit.
Total for Student EE: 1 mark

Student FF

The student has drawn a bar chart instead of a line graph, but has been awarded the compensatory mark as all the bars are at the correct height.
Total for Student FF:1 mark

Student GG

The student has correctly plotted all six points within tolerance but has failed to draw a line of best fit, so the final mark has not been awarded.
Total for Student GG: 2 marks

Example 8: Trilogy Biology 1H question 4.2

Students needed to choose an appropriate scale for the *y*-axis. The grid provided is large enough to use one large square for each 5% change in mass, with two small squares representing 1%, and so if this scale is chosen all the data points should sit on minor grid lines. On the *x*-axis all the data points will sit on major grid lines. This might suggest that the plotting would be standard demand, but the inclusion of negative values increases the demand.

The data provided formed a gentle curve, although students who drew a straight line of best fit were awarded the mark as long as their line averaged out the data.

Student HH

This student has chosen an appropriate scale for the *y*-axis, and has labelled the axis correctly using the heading in the data table, so gain MP1. They have plotted all the points correctly within the tolerance allowed and is awarded both marks for the plotting. However, they have joined the data points using a dot-to-dot line rather than drawing a smooth line of best fit, so does not gain the final mark.
Total for Student HH: 3 marks

Student II

Although this student has labelled the *y*-axis correctly, the scale they have chosen is not appropriate as it uses less than half the available space. All the points were plotted correctly according to their scale, so both plotting marks are awarded. The attempted line of best fit is not continuous, so the mark cannot be awarded.

Total for Student II: 2 marks

Example 9: Trilogy Physics 2F question 3.2

This is a low-demand calculation question. Students are given the equation to apply, and simply need to substitute the numbers given into the equation. There are no transformations or unit conversions.

Student JJ

The student has substituted the numbers correctly (MP1). However, their final answer is wrong because they have multiplied by 9.9, not 9.8 (possibly due to not using their calculator properly) so the second mark is not awarded.

Total for Student JJ: 1 mark

Student KK

The student has not used the equation given, instead choosing to rearrange it and creating an incorrect equation. They cannot gain any marks for substitution into this, as what they have produced is incorrect science. This answer therefore is not worthy of any marks.

Total for Student KK: 0 marks

Student LL

The student has not used the numbers as given in the question but has converted kg into g.

Total for Student LL: 0 marks

Student MM

This is an incorrect answer but because the student has not shown any working the examiner cannot see what they have done to get this answer. It is possible that they have forgotten to put the decimal place into the calculator for 9.8, but as there is no working shown the substitution mark cannot be given.

Total for Student MM: 0 marks

Example 10: Physics 1F questions 6.4 and 6.5

These linked questions are both standard demand: students are prompted to recall the equation and then apply it in 6.5. Students must rearrange the equation to calculate acceleration.

Student NN

The student has simply listed the terms as given alphabetically and added in mathematical operators, creating an incorrect equation.

Total for Student NN: 0 marks

Student OO

The student has given the equation in a rearranged form. Although the expected response would be as given in the specification ($F = m \times a$), correct rearrangements gain full credit. Unfortunately, this student's rearrangement is incorrect.

Total for Student OO: 0 marks

Student PP

This answer is not an equation (there is no '=' here). Even if the first symbol could be interpreted as '=' rather than '×' the equation as given would be incorrect and not creditworthy.

Total for Student PP: 0 marks

Student QQ

The student had correctly recalled the equation in 06.5, and has correctly substituted into the equation, so gains MP1. However, they have then incorrectly rearranged the equation and their answer is wrong, so they gain no further marks.

Total for Student QQ: 1 mark

Student RR

The student has attempted to rearrange the equation and then substitute into the rearranged equation in one step. However, because they have rearranged the equation incorrectly they are substituting into a made-up equation, which demonstrates no understanding of the physics. This answer gains no marks.

Total for Student RR: 0 marks

Example 11: Physics 1H question 9.3

This is a challenging two-step calculation. There are no prompts as to what equations should be used. To answer the question students need to:

- select the equation $E = m \times c \times \Delta\theta$ from the Physics Equations sheet to calculate the mass (there are no marks for this)
- recall the equation $E = P \times t$ and substitute into it, converting 2.53 kW to 2530 W (MP1) to calculate E (MP2)
- substitute into $E = m \times c \times \Delta\theta$ (MP3)
- rearrange to make m the subject of the equation (MP4)
- calculate the final answer (MP5).

Student SS

This student has stated both equations they need to be using (although they get no marks for this), and has correctly calculated E for MP1 and MP2. They have not gone any further with the calculation so do not score any further marks.

Total for Student SS: 2 marks

Student TT

The student substitutes power for energy in the first part of the calculation but corrects this by multiplying by 14 (seconds) in the subsequent step. The power is left in kW so the mass has an incorrect power of 10 and the final mark is not awarded.

Total for Student TT: 4 marks

Student response UU

The student has followed all the steps correctly as shown in the method given in the mark scheme so is awarded all 5 marks.

Total for Student UU: 5 marks

Personal action plan

Following your training session and results of your post-session health check, use this action plan to help continue your development in specific areas.

Personal development aim/target:
What do I need to achieve?
Actions:
Support required:
Measure(s) of success:
Review date(s): **Achievement date:**

Group action plan

Following the group reflection on the session, complete this action plan to support the department's continued development.

Department goal:
Where is the knowledge and expertise?
Actions: Who has ownership of each area?
Support required: How will we work together? How will we hold each other to account?
Measure(s) of success: How will we evidence achievements?
Review date(s): **Achievement date:**

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