

Pearson Edexcel  
**International A Level  
Science**

International A Level Physics Exam  
Insights May/June 2024





# Aims and objectives

1. Receive feedback on the performance of candidates in the June 2024 exam series
2. Consider the variation of candidates' performance on different questions and explore why performance varies
3. Discuss the Examiner's Report
4. Address common issues and FAQs.

# Agenda

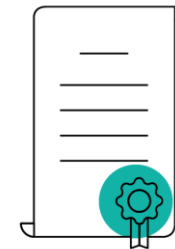
Session	Time
Introduction	3 min
<b>Detailed analysis of questions:</b>	
Strand 1: unstructured calculations	8 min
Strand 2: deduction questions	12 min
Strand 3: explanation questions	10 min
Strand 4: linkage questions	12 min
Strand 5: experimental skills	8 min
Common mistakes (and how to avoid them)	4 min
Support	1 min
Any Questions?	2 min

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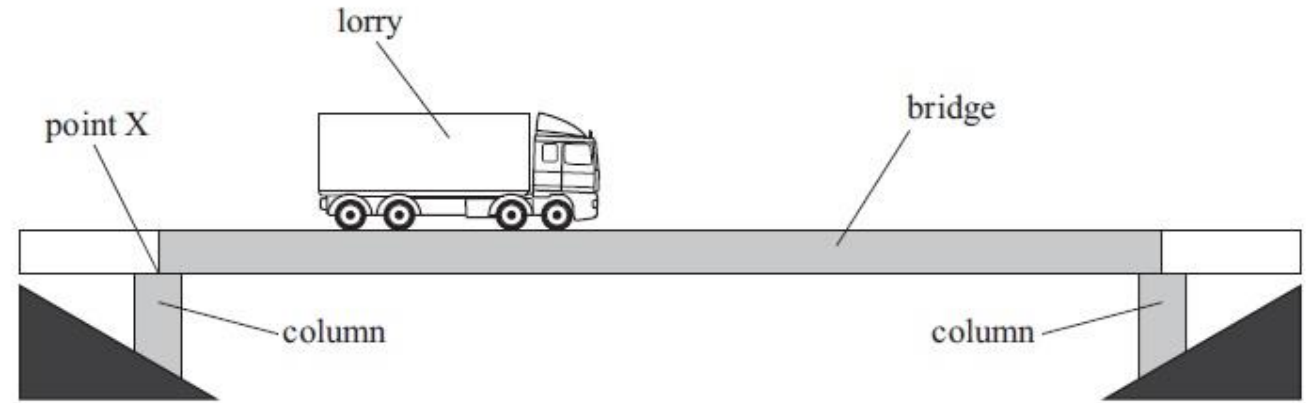


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Examples of Student  
Responses:  
Feedback strand 1:  
unstructured calculations

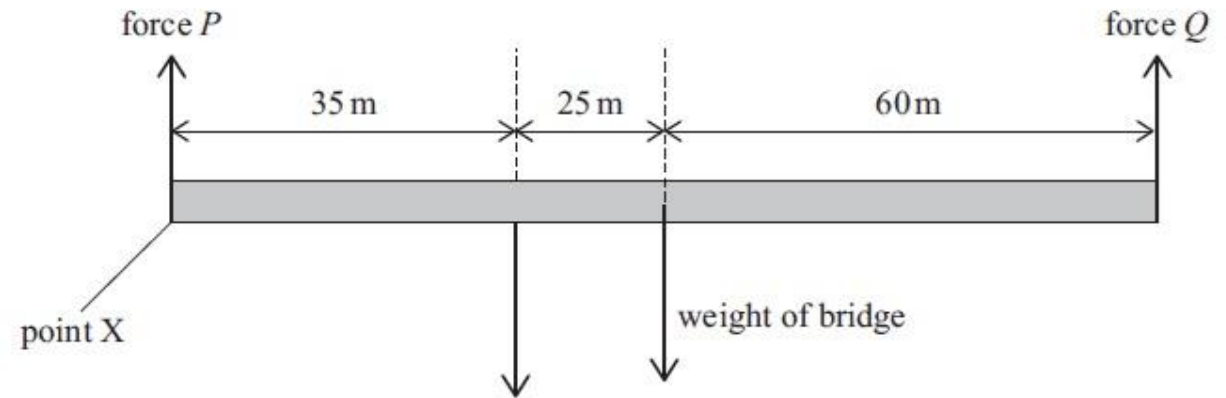
18 A lorry is crossing a bridge. The bridge is supported by two columns, as shown.

WPH11, Q18a



Forces  $P$  and  $Q$  act on the bridge from the columns. The centre of gravity of the bridge is at its centre. At a particular time the lorry is 35 m from point X.

A simplified diagram showing the positions of the forces on the bridge is shown below.



(a) Calculate the magnitudes of the forces  $P$  and  $Q$ .

You should take moments about point X.

$$\text{force from lorry} = 4.2 \times 10^5 \text{ N}$$

$$\text{weight of bridge} = 9.8 \times 10^5 \text{ N}$$

# WPH11, Q18a MS

18(a)	Use of moment of a force = <del><math>Fx</math></del>	(1)	5
	Use of principle of moments	(1)	
	Use of Newton's first law <b>Or</b> Second use of principle of moments	(1)	
	$P = 7.9 \times 10^5 \text{ N}$	(1)	
	$Q = 6.1 \times 10^5 \text{ N}$	(1)	
	Maximum 4 marks if incorrect / no unit with answers.		
	<u>Example of calculation</u>		
	Total clockwise moment = $4.2 \times 10^5 \text{ N} \times 35 \text{ m} + 9.8 \times 10^5 \text{ N} \times 60 \text{ m}$ $= 7.35 \times 10^7 \text{ N m}$		
	Total anticlockwise moment = $Q \times 120 \text{ m}$ $Q \times 120 \text{ m} = 7.35 \times 10^7 \text{ N m}$ $Q = \frac{7.35 \times 10^7 \text{ N m}}{120 \text{ m}} = 6.12 \times 10^5 \text{ N}$		
	$P = 4.2 \times 10^5 \text{ N} + 9.8 \times 10^5 \text{ N} - 6.12 \times 10^5 \text{ N} = 7.88 \times 10^5 \text{ N}$		

# WPH11, Q18a – example 1

(a) Calculate the magnitudes of the forces  $P$  and  $Q$ .

You should take moments about point X.

force from lorry =  $4.2 \times 10^5 \text{ N}$

weight of bridge =  $9.8 \times 10^5 \text{ N}$

(5)

ant:  
the clockwise ~~moment~~ <sup>moment</sup> is  $60\text{m} \times 9.8 \times 10^5 \text{ N} + 4.2 \times 10^5 \text{ N} \times 85\text{m}$   
 $= 945 \times 10^5 \text{ N}\cdot\text{m}$   
 $= 9.45 \times 10^7 \text{ N}\cdot\text{m}$

$$P \cdot (35\text{m} + 25\text{m} + 60\text{m}) = 9.45 \times 10^7 \text{ N}\cdot\text{m}$$

$$\Rightarrow P = 7.875 \times 10^5 \text{ N}$$

$$\text{The clockwise moment is } 35\text{m} \times 4.2 \times 10^5 \text{ N} + \overset{(25\text{m} + 60\text{m})}{25\text{m}} \times 9.8 \times 10^5 \text{ N}$$
$$= 7.35 \times 10^7 \text{ N}\cdot\text{m}$$

$$\text{The force } Q = \frac{\text{clockwise moment}}{(35\text{m} + 25\text{m} + 60\text{m})}$$
$$= 6.125 \times 10^5 \text{ N}$$

$$P = 7.875 \times 10^5 \text{ N}$$

$$Q = 6.125 \times 10^5 \text{ N}$$



# WPH11, Q18a – example 2

(a) Calculate the magnitudes of the forces  $P$  and  $Q$ .

You should take moments about point X.

force from lorry =  $4.2 \times 10^5 \text{ N}$

weight of bridge =  $9.8 \times 10^5 \text{ N}$

(5)

⇒ For force  $P$

$$F_1 d_1 = F_2 d_2$$

$$4.2 \times 10^5 \times 35 = F_2 \times 25$$

$$1.47 \times 10^7 = F_2 \times 25$$

$$F_2 = \frac{1.47 \times 10^7}{25} = 5.88 \times 10^5$$

$$\therefore m = \frac{W}{g} = \frac{9.8 \times 10^5}{9.81} = 9.99 \times 10^4$$

$$\text{Force } P = 5.88 \times 10^5 - 9.99 \times 10^4$$

$$= 4.88 \times 10^5 \text{ N}$$

⇒ For force  $Q$

$$F_1 d_1 = F_2 d_2$$

$$4.2 \times 10^5 \times 25 = F_2 \times 60$$

$$1.05 \times 10^7 = F_2 \times 60$$

$$F_2 = \frac{1.05 \times 10^7}{60} = 1.75 \times 10^5$$

$$\text{For force } Q = 1.75 \times 10^5 - 9.99 \times 10^4$$

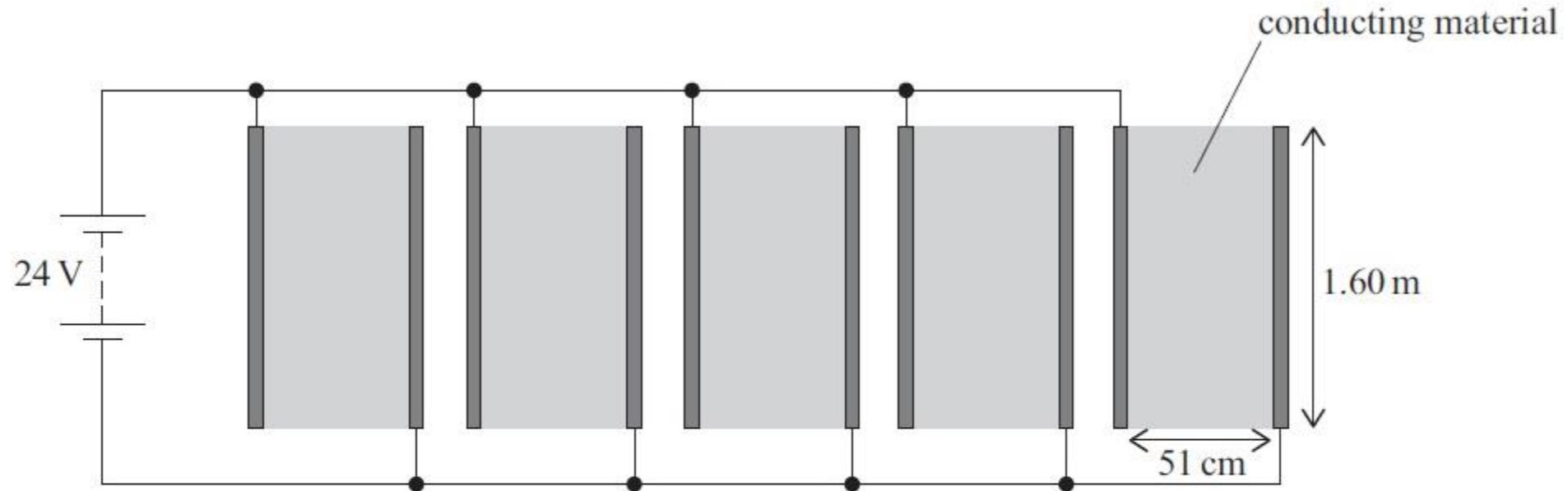
$$= 7.51 \times 10^4 \text{ N}$$

$$P = 4.9 \times 10^5 \text{ N}$$

$$Q = 7.5 \times 10^4 \text{ N}$$

Examples of Student  
Responses:  
Feedback strand 2:  
deduction questions

(d) A student designs a heating system using five heating panels, as shown.



To be safe, the maximum power of the student's heating system should be less than 350 W.

Deduce whether the student's heating system is safe.

resistivity of conducting material =  $6.4 \times 10^{-3} \Omega \text{ m}$

thickness of conducting material = 0.48 mm

(5)

# WPH12, Q14d

14(d)	Calculate area using $1.60 \times \text{thickness}$	(1)	5
	Use of $R = \frac{\rho l}{A}$	(1)	
	Use of resistors in parallel formula	(1)	
	Use of $P = \frac{V^2}{R}$	(1)	
	680 W is greater than 350 W so the system is not safe	(1)	
	<b>OR</b>		
	Calculate area using $1.60 \times \text{thickness}$	(1)	
	Use of $R = \frac{\rho l}{A}$	(1)	
	Use of $P = \frac{V^2}{R}$	(1)	
	Multiplies calculated power x 5	(1)	
	680 W is greater than 350 W so the system is not safe	(1)	
	<u>Example of calculation</u>		
	$A = 1.60 \text{ m} \times 0.48 \times 10^{-3} \text{ m} = 7.68 \times 10^{-4} \text{ m}^2$		
	$R = \frac{6.4 \times 10^{-3} \Omega \text{ m} \times 0.51 \text{ m}}{7.68 \times 10^{-4} \text{ m}^2} = 4.25 \Omega$		
	$R_{\text{total}} = \frac{4.25 \Omega}{5} = 0.85 \Omega$		
	$P = \frac{(24 \text{ V})^2}{0.85 \Omega} = 678 \text{ W}$		

# WPH12, Q14d – example 1

Deduce whether the student's heating system is safe.

resistivity of conducting material =  $6.4 \times 10^{-3} \Omega \text{m}$

thickness of conducting material = 0.48 mm

(5)

$$R = \frac{\rho L}{A}$$

$$R = \frac{6.4 \times 10^{-3} (1.60)}{4.8 \times 10^{-4} (5)}$$

$$R = 41.83 \Omega$$

$$P = 5 \left( \frac{V}{R} \right)^2$$

$$P = 5 \left( \frac{24}{41.83} \right)^2$$

$$P = 68.9 \text{ W}$$

Yes so the heating system is safe.

# WPH12, Q14d – example 2

Deduce whether the student's heating system is safe.

resistivity of conducting material =  $6.4 \times 10^{-3} \Omega \text{m}$

thickness of conducting material = 0.48 mm

(5)

$$R = \frac{\rho L}{A}$$

$$R = \frac{6.4 \times 10^{-3} \times 1.60}{1.60 \times 0.91 \times 0.48 \times 10^{-3}}$$

$$51 \text{ cm} \rightarrow 0.51$$

$$R = \frac{\rho L}{A}$$

$$R = \frac{6.4 \times 10^{-3} \times 0.51}{1.60 \times 5 \times 0.48 \times 10^{-3}}$$

$$R = 26.14$$

$$R = 0.89 \Omega$$

$$P = \frac{V^2}{R}$$

$$P = \frac{24^2}{26.14}$$

$$P = \frac{V^2}{R}$$

$$P = \frac{24^2}{0.89}$$

The student heating system is not safe

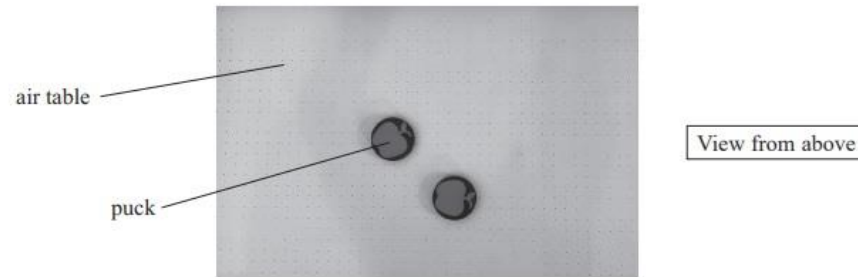
$$677.6 > 350 \text{ W}$$

(Total for Question 14 = 14 marks)

# WPH14, Q15bi

- 15 An air table has a surface with many small holes. Air is blown through the holes. Plastic pucks can move freely over the table on a cushion of air.

The photograph shows the surface of an air table with two pucks on it.

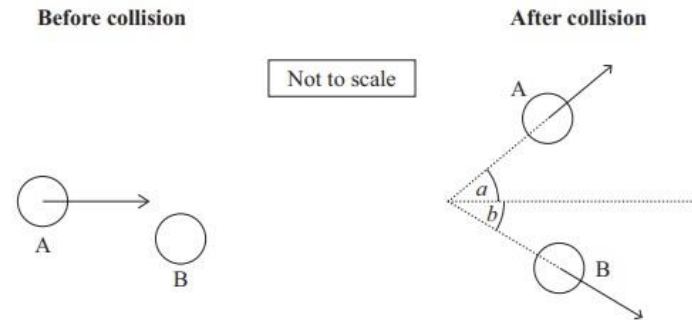


Some students used the air table to investigate conservation of momentum.

- (b) The students observed several collisions between two identical pucks, A and B. One puck was stationary before each collision.

They noticed that after each collision the two pucks seemed to follow paths at  $90^\circ$  to each other.

The diagram shows one of the collisions.



The students recorded the following data for this collision.

initial momentum of A	$0.046 \text{ kg m s}^{-1}$
angle $a$	$33^\circ$
final momentum of A	$0.039 \text{ kg m s}^{-1}$

- (i) Deduce whether the angle between the paths of the pucks after the collision was  $90^\circ$ .

You should use the principle of conservation of momentum.



# WPH14, Q15bi MS

15(b)(i)	<p>Use of trigonometrical function for <math>x</math> component of A momentum after collision  <b>Or</b> Use of trigonometrical function for <math>y</math> component of A momentum after collision (1)</p> <p>Applies conservation of momentum (1)</p> <p>Applies trigonometry to calculate final angle for B (1)</p> <p>Angle between A and B = <math>91^\circ</math> (1)</p> <p>Comparison between calculated angle and <math>90^\circ</math> including conclusion in words (1)</p> <p><u>Example of calculation</u></p> <p><math>x</math> component of A after = <math>0.039 \text{ kg m s}^{-1} \times \cos 33^\circ = 0.0327 \text{ kg m s}^{-1}</math>  <math>y</math> component of A after = <math>0.039 \text{ kg m s}^{-1} \times \sin 33^\circ = 0.0212 \text{ kg m s}^{-1}</math>  <math>x</math> component of B after = <math>0.046 \text{ kg m s}^{-1} - 0.0327 \text{ kg m s}^{-1} = 0.0133 \text{ kg m s}^{-1}</math>  <math>y</math> component of B after = <math>0.0212 \text{ kg m s}^{-1}</math>  <math>\tan \theta = 0.0212 \text{ kg m s}^{-1} \div 0.0133 \text{ kg m s}^{-1} = 1.59</math>  <math>\theta = 57.9^\circ</math>  <math>58^\circ + 33^\circ = 91^\circ</math> which is about <math>90^\circ</math></p>	5
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# WPH14, Q15bi – example 1

- (i) Deduce whether the angle between the paths of the pucks after the collision was  $90^\circ$ .

You should use the principle of conservation of momentum.

(5)

Horizontally ( $\leftrightarrow$ )

$$P_{ab} = mv = 0.046 \text{ kgms}^{-1}$$

~~$0.046$~~

$$P_{aH} = P_a \cdot \cos a$$

$$= 0.039 \cdot \cos 33^\circ$$

$$= 0.033 \text{ kgms}^{-1}$$

$$P_{ab} - P_{aH} = P_{bH} = 0.013 \text{ kgms}^{-1}$$

Vertically ( $\updownarrow$ )

$$P_{aV} = P_a \cdot \sin a$$

$$= 0.039 \cdot \sin 33^\circ$$

$$P_{aV} = 0.021 \text{ kgms}^{-1}$$

$$P_{bV} = P_{aV} = 0.021 \text{ kgms}^{-1}$$

$$P_{Ba}^2 = P_{bV}^2 + P_{bH}^2$$

$$P_{Ba}^2 = 0.013^2 + 0.021^2$$

$$P_{Ba} = 0.025 \text{ kgms}^{-1}$$

$$\tan b = \frac{P_{bV}}{P_{bH}} = \frac{0.021}{0.013}$$

$$\tan b = 1.623$$

$$b = 62.5^\circ$$

$$a + b = 95.5^\circ$$

$95.5^\circ \neq 90^\circ$ , it's ~~not~~ not  $90^\circ$ .

## WPH14, Q15bi – example 2

- (i) Deduce whether the angle between the paths of the pucks after the collision was  $90^\circ$ .

You should use the principle of conservation of momentum.

(5)

$$0.039 \times \cos 33^\circ = 0.0327 \text{ kgms}^{-1}$$

$$0.046 - 0.0327 = 0.0133 \text{ kgms}^{-1}$$

$$0.039 \times \sin 33^\circ = 0.0212 \text{ kgms}^{-1}$$

$$\tan^{-1}\left(\frac{0.0212}{0.0133}\right) = 86.4^\circ$$

$$\sqrt{0.0133^2 + 0.0212^2}$$

$$= 0.025 \text{ kgms}^{-1}$$

$$\tan^{-1}\left(\frac{0.0212}{0.0133}\right) = 57.9^\circ$$

$$57.9^\circ + 33^\circ = 90.9^\circ$$

$$90.9^\circ \approx 90^\circ$$

# WPH15, Q15b with MS

15 The photograph shows a large area of ice floating in the sea. This is called an ice floe.



(Source: © elmvilla/Getty Images)

Energy from the Sun melts the ice floe.

(a) An ice floe has a mass of  $3.53 \times 10^5 \text{ kg}$ .

Show that the energy required to melt this ice floe is about  $1.3 \times 10^{11} \text{ J}$ .

(b) At the top of the atmosphere, the intensity of radiation from the Sun is  $1370 \text{ W m}^{-2}$ . As radiation passes through the atmosphere, 44% is absorbed or reflected by the atmosphere.

A scientist claims that, even with continuous sunshine, the time taken for the ice floe to melt completely would be greater than 7 days.

Deduce whether this claim is correct.

average thickness of ice floe =  $0.85 \text{ m}$

volume of ice floe =  $385 \text{ m}^3$

1 day =  $8.64 \times 10^4 \text{ s}$

15(b)	Surface area of top of ice floe calculated [ $453 \text{ m}^2$ ]	(1)	
	Intensity at sea level calculated using 56% [ $767 \text{ W m}^{-2}$ ]	(1)	
	Use of $I = \frac{P}{A}$	(1)	
	Use of $P = \frac{\Delta W}{\Delta t}$	(1)	
	$t = 4.4 \text{ days}$ [4.3 days if "show that" value used] (ecf from (a))	(1)	
	Or $E = 2.10 \times 10^{11} \text{ J}$ for 7 days		
	4.4 days is less than 7 days so claim is not correct		
	Or $1.32 \times 10^{11} \text{ J} < 2.10 \times 10^{11} \text{ J}$ so claim is not correct		
	Or Correct conclusion based on comparison of candidate's calculated values	(1)	6
	<u>Example of calculation</u>		
	$P = 0.56 \times 1370 \text{ W m}^{-2} \times 453 \text{ m}^2 = 3.48 \times 10^5 \text{ W}$		
	$t = \frac{1.32 \times 10^{11} \text{ J}}{3.48 \times 10^5 \text{ J s}^{-1}} = 3.79 \times 10^5 \text{ s}$		
	$t = \frac{3.79 \times 10^5 \text{ s}}{8.64 \times 10^4 \text{ s day}^{-1}} = 4.39 \text{ days}$		

# WPH15, Q15b – ex 1

- (b) At the top of the atmosphere, the intensity of radiation from the Sun is  $1370 \text{ W m}^{-2}$ . As radiation passes through the atmosphere, 44% is absorbed or reflected by the atmosphere.

A scientist claims that, even with continuous sunshine, the time taken for the ice floe to melt completely would be greater than 7 days.

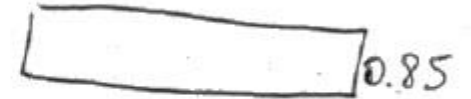
Deduce whether this claim is correct.

average thickness of ice floe =  $0.85 \text{ m}$

volume of ice floe =  $385 \text{ m}^3$

1 day =  $8.64 \times 10^4 \text{ s}$

$$V = 385$$



$$I_{\text{top}} = 1370 \cdot (1 - 0.44) = 767 \text{ W m}^{-2}$$

(6)

$$A = \frac{385}{0.85} = 447 \text{ m}^2$$

$$P = 767 \cdot 447 = 3.43 \cdot 10^5 \text{ W}$$

$$\frac{1.32 \cdot 10^{11}}{3.43 \cdot 10^5} = 3.85 \cdot 10^5 \text{ s}$$

$$\frac{3.85 \cdot 10^5}{8.64 \cdot 10^4} = 4.45 \text{ days}$$

$\therefore$  The claim is wrong as the ice melts in 4.45 days

(Total for Question 15 = 9 marks)



## WPH15, Q15b – example 2

- (b) At the top of the atmosphere, the intensity of radiation from the Sun is  $1370 \text{ W m}^{-2}$ .  
As radiation passes through the atmosphere, 44% is absorbed or reflected by the atmosphere.  $I$

A scientist claims that, even with continuous sunshine, the time taken for the ice floe to melt completely would be greater than 7 days.

Deduce whether this claim is correct.

average thickness of ice floe = 0.85 m  
volume of ice floe =  $385 \text{ m}^3$   
1 day =  $8.64 \times 10^4 \text{ s}$

(6)

$$A_{\text{ice}} = \frac{385}{0.85} = \cancel{453 \text{ m}} \quad 453 \text{ m}^2$$

$$P = I \cdot A = 1370 \times 44\% \times 453 = 2.73 \times 10^5 \text{ W}$$

$$\cancel{W} \quad W = Pt = 2.73 \times 10^5 \times 8.64 \times 10^4 \times 7 = 1.65 \times 10^{11} \text{ J}$$

$$1.65 \times 10^{11} \text{ J} > 1.32 \times 10^{11} \text{ J}$$

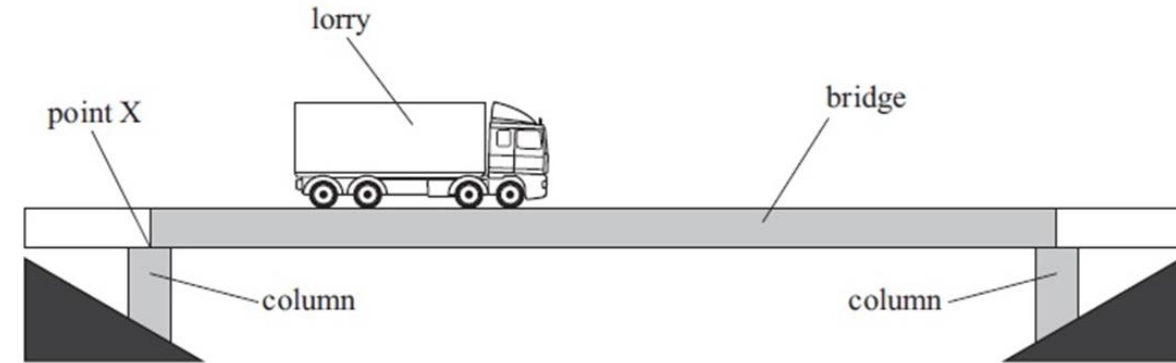
The time taken is less than 7 days so  
the claim is incorrect.

Examples of Student  
Responses:  
Feedback strand 3:  
explanation questions

# WPH11, Q18b with MS

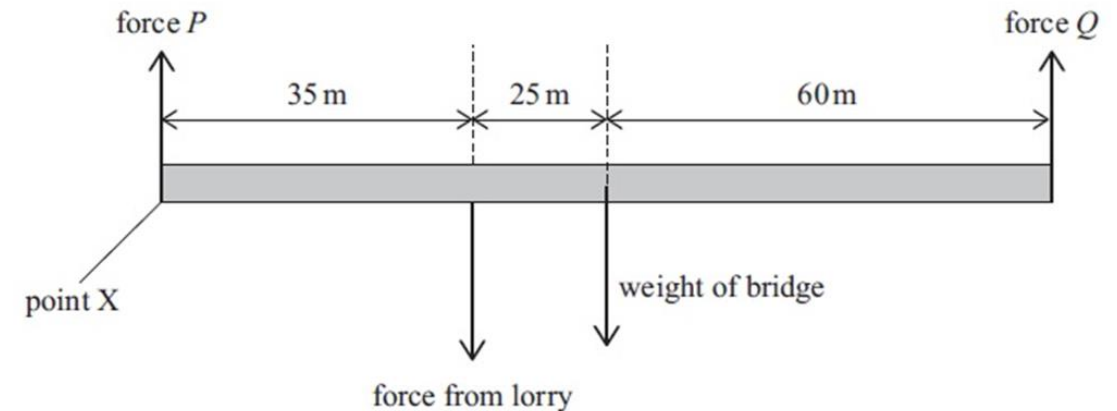
<b>18(b)</b>	<p>Allow P for X throughout Allow Q for Y throughout</p> <p><b>EITHER</b></p> <p>Distance from X to (centre of gravity of) lorry increases (1)</p> <p>(So) moment (about X) due to (force from) lorry increases (1)</p> <p>Sum of moments remains zero (for equilibrium) (1)</p> <p>So moment (about X) due to <math>Q</math> increases (1)</p> <p>Distance from X to <math>Q</math> remains the same therefore <math>Q</math> increases (1)</p> <p><b>OR</b></p> <p>Distance from other end of bridge (Y) to (centre of gravity of) lorry decreases (1)</p> <p>(So) moment about Y due to (force from) lorry decreases (1)</p> <p>Sum of moments remains zero (for equilibrium) (1)</p> <p>So moment about Y due to <math>P</math> decreases, and <math>P</math> must decrease (1)</p> <p>And (at equilibrium) the sum of <math>P</math> and <math>Q</math> remains the same therefore <math>Q</math> increases (1)</p>
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18 A lorry is crossing a bridge. The bridge is supported by two columns, as shown.



Forces  $P$  and  $Q$  act on the bridge from the columns. The centre of gravity of the bridge is at its centre. At a particular time the lorry is 35 m from point X.

A simplified diagram showing the positions of the forces on the bridge is shown below.



(b) Explain why force  $Q$  increases as the lorry moves across the bridge.

(5)

# WPH11, Q18b – example 1

(b) Explain why force  $Q$  increases as the lorry moves across the bridge.

(5)

- As the lorry moves across the bridge, past halfway it is not acting on the center of mass of the bridge  $\therefore$  weight is not evenly distributed. The lorry would be causing a 'turning force' <sup>clockwise</sup> which Force  $Q$ , the column has to counter and produce a greater anti-clockwise moment to ensure the bridge is stable. The lorry produces a clockwise moment about the centre of gravity, <sup>and any other point of the bridge</sup> since  $M = Fd$ , the further away the lorry gets the greater the turning force produced. This resultant force needs to be countered.



## WPH11, Q18b – example 2

(b) Explain why force  $Q$  increases as the lorry moves across the bridge.

(5)

Take  $P$  as the pivot. Let the distance between  $P$  and the lorry be  $x$ .

Moment clockwise =  $W_L x + 60W$ , and  $W_L$  and  $W$  are constant

Moment anticlockwise =  $F_a \times 120$

Since it is in equilibrium, the resultant moment is zero.

$$120 F_a = \cancel{W_L x + 60W} = W_L x + 60W$$

Then when  $x$  increases,  $F_a$  would increase.

# WPH15, Q18bii with MS

(b) Luminosity measurements suggest that our galaxy has a mass equal to  $8.0 \times 10^{11}$  solar masses.

(i) A star in one of the outer arms of the galaxy is orbiting the centre of the galaxy.  
The star is  $5.7 \times 10^{20}$  m from the centre of the galaxy.

Show that the orbital period of the star should be about  $8 \times 10^{15}$  s.

(ii) The orbital period of the star is actually  $6.0 \times 10^7$  s.

The two values for the orbital period of the star do not agree.

Deduce what this tells us about our galaxy.

Assume that the value for the distance of the star from the centre of our galaxy is correct.

18(b)(ii)	The actual period is (much) smaller than the calculated value	(1)	4
	So the mass of the galaxy must be greater than $8.0 \times 10^{11}$ solar masses [accept the given mass for the numerical value]		
	Or the gravitational force on the star must be bigger (than assumed)	(1)	
	There must be matter that does not emit em-radiation Or There must be matter that we cannot detect via em-radiation [Accept “there must be matter that we cannot see”]	(1)	
	(This suggests that) there is dark matter	(1)	

## WPH15, Q18bii

### Example 1

(ii) The orbital period of the star is actually  $6.0 \times 10^7$  s.

The two values for the orbital period of the star do not agree.

Deduce what this tells us about our galaxy.

Assume that the value for the distance of the star from the centre of our galaxy is correct.

(4)

The actual orbital period of the star is much smaller compared to the calculated value. This indicates that the mass of the galaxy must be much greater than the mass taken from luminosity measurements. This concludes that there must be matter in our galaxy that doesn't emit electromagnetic radiation, also known as dark matter.  $\therefore$  this tells that our galaxy contains dark matter which we can't detect which means we wasn't know its actual mass from its Luminosity.

## WPH15, Q18bii

### Example 2

(ii) The orbital period of the star is actually  $6.0 \times 10^7$  s.

The two values for the orbital period of the star do not agree.

Deduce what this tells us about our galaxy.

Assume that the value for the distance of the star from the centre of our galaxy is correct.

(4)

The actual orbital period is much smaller than the one calculated. This means that the velocity of the star ( $v = \frac{2\pi r}{T}$  where  $r$  is correct) is a lot larger than it should be.  <sup>$v_{act}$</sup>  The gravitational pull of the galaxy is not large enough to keep this star with such a speed in orbit, so we conclude that there must be some kind of matter holding the galaxy together, that we call dark matter, providing this extra gravitational force needed.

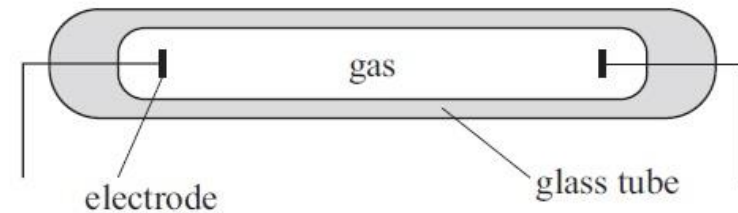
Examples of Student  
Responses:  
Feedback strand 4:  
linkage questions



# WPH12, Q17aii with MS

17 In the second half of the 19th century, scientists began to investigate interactions between photons and electrons.

(a) A discharge tube is a glass tube containing gas, as shown.



When the discharge tube is connected into an electrical circuit, the gas atoms emit photons. The photons have specific frequencies.

\*(ii) The electrical circuit applies a large potential difference (p.d.) across the discharge tube.

Explain how the p.d. across the discharge tube causes photons to be emitted by the gas atoms.

IC1 The potential difference causes a current in the gas / tube

IC2 So energy is transferred to the gas atoms

IC3 Electron/atom gains (sufficient) energy to move up energy levels

IC4 An (excited) electron (is unstable and) falls back down emitting a photon

IC5 With a wavelength/frequency corresponding to the difference in the energy levels Or reference to  $E = hf$  or  $E \propto f$

IC6 Electrons/atoms exist in discrete/fixed/certain energy levels so only certain frequencies / wavelengths are emitted

# WPH12, Q17aii – example 1

Explain how the p.d. across the discharge tube causes photons to be emitted by the gas atoms.

||||

(6)

Higher voltage means that ~~a higher~~ the current across the discharge tube ~~is~~ is higher. The release of ~~electrons~~ <sup>photons photoelectrons</sup> from an atom is instantaneous. So when the intensity increases, the ~~rate~~ rate of ~~photon~~ <sup>photoelectrons</sup> released ~~increases~~ increases <sup>as one</sup> ~~one~~ photon interacts with one electron. The increase in current supply increases the photon energy absorbed by the hydrogen atoms. If this energy is higher than the work function, photoelectrons will be released. Depending on the energy of the photon, the frequency will also vary. ~~If~~ If this frequency is higher than the threshold frequency, then photon electrons will be released. ~~Photon~~ as ~~phot~~ the photon energy is relative to the frequency.

## WPH12, Q17a(ii) – example 2

Explain how the p.d. across the discharge tube causes photons to be emitted by the gas atoms.

(6)

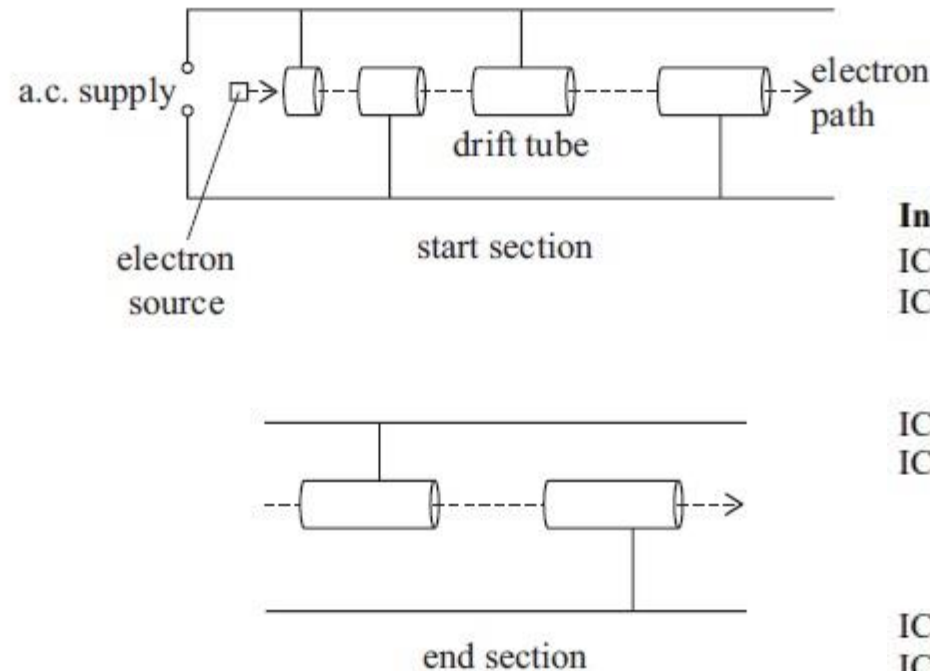
gas atoms absorb <sup>electrons</sup> ~~photons~~. Since  $E = VQ$  larger the potential difference more the energy. When the energy of the <sup>electron</sup> ~~photon~~ is greater

$E = hf = Q + \frac{1}{2}mv^2$  the electrons gain energy and move to a higher energy level where they are excited. When the electrons get de-excited they move to lower energy level emitting a photon. Energy levels are discrete and the difference in energy levels is the energy of the photon. Energy is directly proportional to the frequency. Electrons require minimum threshold frequency to be emitted.



# WPH14, Q16b with MS

\*(b) The diagram shows the start section of a linac and the end section of a linac.



## Indicative content

- IC1 The electrons are accelerated by an electric field between the drift tubes
- IC2 The (a.c) polarity changes (when the electrons are in the tubes) so the (electric) field is in the same direction when the particle is in the gaps  
**Or** The (a.c.) polarity changes so it is always accelerating the particles
- IC3 The a.c. frequency is constant
- IC4 The length of the drift tubes increases (along the Linac) so the electrons spend the same time in the tubes / gaps  
**Or** The length of the gaps increases (along the Linac) so the electrons spend the same time in the tubes / gaps
- IC5 The tubes have constant length at the end
- IC6 As the electrons approach (but do not achieve) the speed of light their speed no longer increases

Explain how a linac produces high energy electrons.

You should refer to the a.c. supply and to the length of the drift tubes in each section.

# WPH14, Q16b – example 1

Explain how the p.d. across the discharge tube causes photons to be emitted by the gas atoms.

||||

(6)

Higher voltage means that ~~a higher~~ the current across the discharge tube ~~is~~ is higher. The release of ~~electrons~~ <sup>photoelectrons</sup> from an atom is instantaneous. So when the intensity increases, the rate of ~~photon~~ <sup>photoelectrons</sup> released ~~increases~~ increases <sup>as one</sup> ~~the~~ photon interacts with one electron. The increase in current supply increases the photon energy absorbed by the hydrogen atoms. If this energy is higher than the work function, photoelectrons will be released. Depending on the energy of the photon, the frequency will also vary. ~~If~~ If this frequency is higher than the threshold frequency, then photon electrons will be released. ~~Photon~~ as ~~phot~~ the photon energy is relative to the frequency.

## WPH14, Q16b – example 2

When an electron is produced by the source, it is accelerated by an electric field produced by a.c current to the first tube. Then just before leaving the first tube, the electric field changes direction so that it is accelerated towards the next tube. The change in field direction is done by constant frequency of a.c supply which produces alternating magnetic field. As the ~~part~~ electron accelerates, its speed increases. To keep the frequency of ac supply constant, the tubes are elongated one after another, so that the electron spend the same time in each tube, according to  $S = vt$ . However, when near the end sections, the speed of the electrons are so high, ~~th~~ it reaches relativistic speed. So speed stop increasing and mass starts increasing. Thus, the tubes also stop increasing in length near the end section.

Examples of Student  
Responses:  
Feedback strand 5:  
experimental skills



# WPH13, Q3b with MS

**3(b)** Calculates time  $t = \text{number of divisions} \times \text{time per division}$  (1)

Use of  $v = \frac{s}{t}$

(1)

Uses  $2 \times s$

**Or** Uses  $\frac{1}{2} \times t$

(1)

$v = 331 \text{ (m s}^{-1}\text{)}$

(1)

4

Example of calculation

$t = 6 \text{ divisions} \times 0.5 \text{ ms per division} = 3 \text{ ms}$

$v = \frac{s}{t} = \frac{2 \times 0.497 \text{ m}}{3 \times 10^{-3} \text{ s}} = 331.3 \text{ m s}^{-1}$

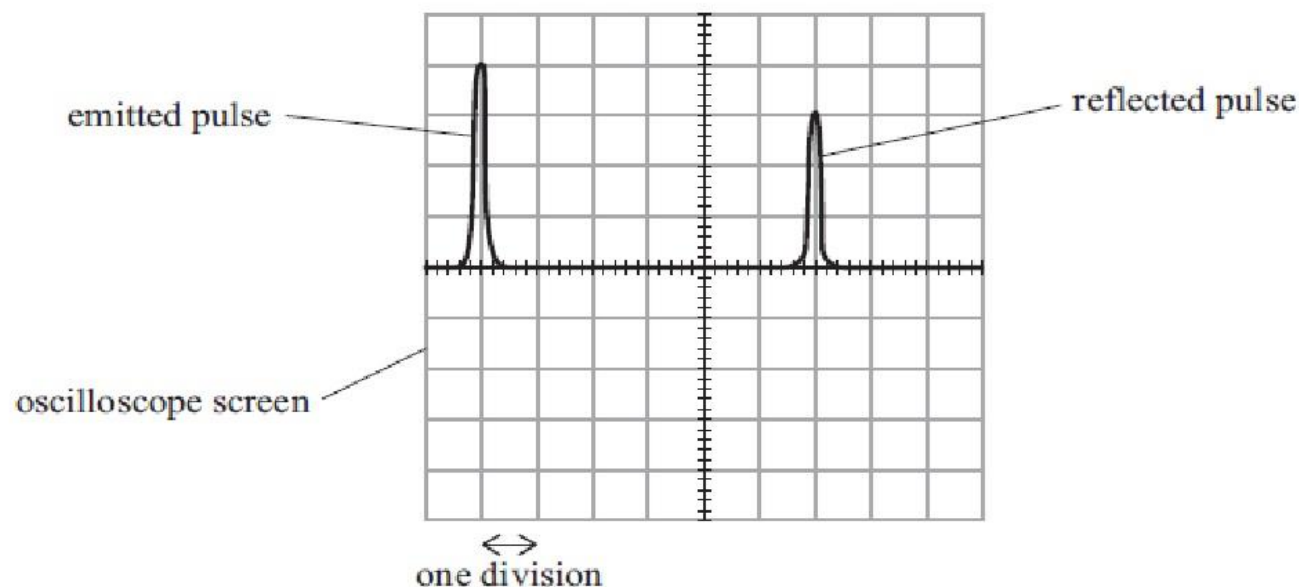
3 A student determined the speed of ultrasound in air using an ultrasound transducer.

(b) The ultrasonic transducer emitted pulses of ultrasound.

The emitted pulses were reflected at the water surface and then detected when they returned to the ultrasonic transducer.

The student connected an oscilloscope to the transducer, to determine the time between an emitted pulse and the reflected pulse.

The oscilloscope screen is shown below.



The horizontal axis represents time.

The time scale was set to  $0.5 \text{ ms per division}$ .

Show that, for this example, the speed  $v$  of ultrasound in air was about  $330 \text{ m s}^{-1}$ .

length of air column  $s = 49.7 \text{ cm}$

# WPH13, Q3b – example 1

Show that, for this example, the speed  $v$  of ultrasound in air was about  $330 \text{ m s}^{-1}$ .

length of air column  $s = 49.7 \text{ cm}$

(4)

$$v = \frac{s}{t}$$

$$v = \frac{2 \times (49.7 \times 10^{-2})}{0.5 \times 6 \times 10^{-3}} = 331.3 \text{ m/s} \approx 330 \text{ m/s}$$

$$\text{time} = 6 \times (0.5 \times 10^{-3})$$

$$\text{distance} = 2 \times s \text{ (in order to travel and be reflected back)}$$

## WPH13, Q3b – example 2

Show that, for this example, the speed  $v$  of ultrasound in air was about  $330 \text{ m s}^{-1}$ .

length of air column  $s = 49.7 \text{ cm}$

(4)

$$\cancel{0.5 \text{ ms} \times 10 = 5 \text{ ms}}$$

$$\frac{49.7 \text{ cm}}{100} = 0.497 \text{ m}$$

$$\frac{0.5 \text{ ms}}{1000} = 5 \times 10^{-4} \text{ s}$$

$$5 \times 10^{-4} \times 10 = 5 \times 10^{-3} \text{ s}$$

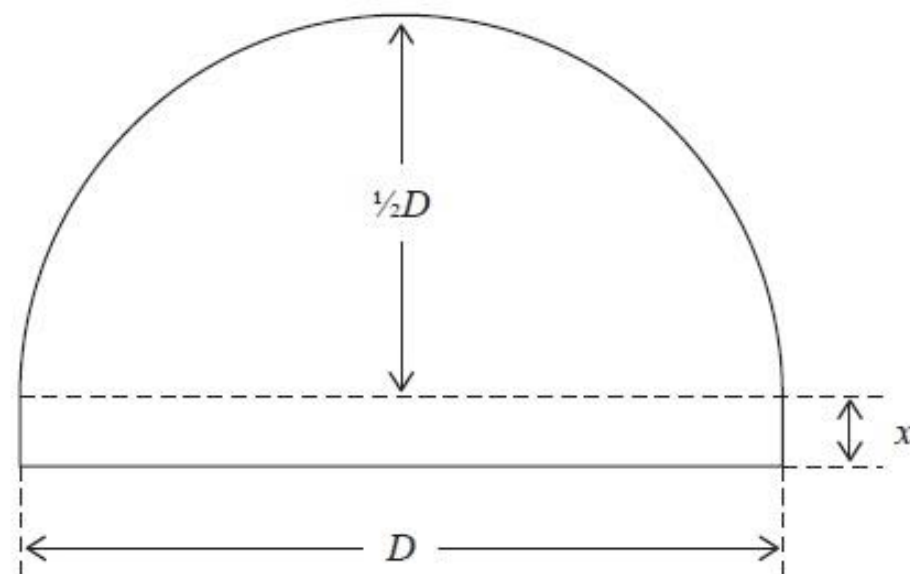
$$2s = 0.994 \text{ m} \therefore \frac{0.994}{2.5 \times 10^{-3}} = 397.6 \text{ m s}^{-1}$$

$5 \times 10^{-3} \times \frac{1}{2}$  since time should be halved since wave is reflected.

length is doubled since the wave is reflected.

# WPH16, Q4b

- (b) The student determined the volume  $V$  of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$$D = 10.10 \text{ cm} \pm 0.05 \text{ cm}$$

$$x = 4.5 \text{ mm} \pm 0.1 \text{ mm}$$

$$t = 1.40 \text{ mm} \pm 0.02 \text{ mm}$$

- (i) Show that  $V$  is about  $6.2 \text{ cm}^3$ .

(2)

- (ii) Show that the uncertainty in  $V$  is about  $0.2 \text{ cm}^3$ .

(4)

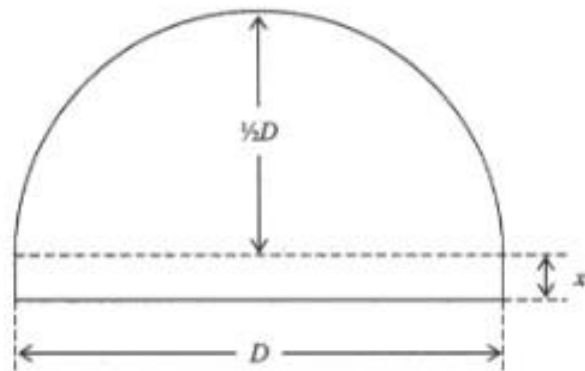


# WPH16, Q4b MS

4(b)(i)	<p>Uses <math>V = (\text{area of semicircle} + \text{area of rectangle}) \times \text{thickness}</math> (1)</p> <p><math>V = 6.24 \text{ (cm}^3\text{)}</math> (1)</p> <p><u>Example of calculation</u></p> <p>Volume of semicircle <math>= \frac{\pi D^2 t}{8} = \frac{\pi \times (10.1 \text{ cm})^2 \times 0.14 \text{ cm}}{8} = 5.608 \text{ cm}^3</math></p> <p>Volume of rectangle <math>= 10.1 \text{ cm} \times 0.45 \text{ cm} \times 0.14 \text{ cm} = 0.636 \text{ cm}^3</math></p> <p><math>V = 5.608 \text{ cm}^3 + 0.636 \text{ cm}^3 = 6.24 \text{ cm}^3</math></p>	2
4(b)(ii)	<p><b>EITHER</b></p> <p>Doubles %U in <math>D</math> Accept doubles <math>\frac{\Delta D}{D}</math> (1)</p> <p>Correct calculation of %U in <math>\frac{\pi D^2 t}{8}</math> (1)</p> <p><b>Or</b> Correct calculation of %U in <math>Dxt</math> (1)</p> <p>Calculation of U in <math>\frac{\pi D^2 t}{8}</math> and U in <math>Dxt</math> (1)</p> <p><math>U = 0.16 \text{ (cm}^3\text{)}</math> (1)</p> <p><u>Example of calculation</u></p> <p>%U in <math>D = 0.5\%</math></p> <p>%U in <math>x = 2.2\%</math></p> <p>%U in <math>t = 1.4\%</math></p> <p>%U in <math>\frac{\pi D^2 t}{8} = (2 \times 0.5\%) + 1.4\% = 2.4\%</math></p> <p>%U in <math>Dxt = 0.5\% + 2.2\% + 1.4\% = 4.1\%</math></p> <p>U in <math>V = (5.61 \text{ cm}^3 \times 2.4\%) + (0.64 \text{ cm}^3 \times 4.1\%) = 0.135 \text{ cm}^3 + 0.026 \text{ cm}^3</math></p> <p><math>= 0.16 \text{ (cm}^3\text{)}</math></p> <p><b>OR</b></p> <p>Uses maximum values to calculate maximum <math>V</math> (1)</p> <p><b>Or</b> Uses minimum values to calculate minimum <math>V</math> (1)</p> <p>Maximum <math>V = 6.40 \text{ (cm}^3\text{)}</math> <b>Or</b> minimum <math>V = 6.08 \text{ (cm}^3\text{)}</math> (1)</p> <p>Correct calculation of half range (1)</p> <p><math>U = 0.16 \text{ (cm}^3\text{)}</math></p> <p><u>Example of calculation</u></p> <p>Maximum <math>V = \frac{\pi \times (10.15 \text{ cm})^2 \times 0.142 \text{ cm}}{8} + 10.15 \text{ cm} \times 0.46 \text{ cm} \times 0.142 \text{ cm}</math></p> <p><math>= 5.74 \text{ cm}^3 + 0.66 \text{ cm}^3 = 6.40 \text{ (cm}^3\text{)}</math></p> <p>Minimum <math>V = \frac{\pi \times (10.05 \text{ cm})^2 \times 0.138 \text{ cm}}{8} + 10.05 \text{ cm} \times 0.44 \text{ cm} \times 0.138 \text{ cm}</math></p> <p><math>= 5.47 \text{ cm}^3 + 0.61 \text{ cm}^3 = 6.08 \text{ (cm}^3\text{)}</math></p> <p>U in <math>V = \frac{(6.40 - 6.08) \text{ cm}^3}{2} = 0.16 \text{ (cm}^3\text{)}</math></p>	4

# WPH16, Q4b – example 1

- (b) The student determined the volume  $V$  of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$$D = 10.10 \text{ cm} \pm 0.05 \text{ cm}$$

$$x = 4.5 \text{ mm} \pm 0.1 \text{ mm}$$

$$t = 1.40 \text{ mm} \pm 0.02 \text{ mm}$$

- (i) Show that  $V$  is about  $6.2 \text{ cm}^3$ .

(2)

$$10.10 \div 2 = 5.05 \text{ cm} \quad 1.4 \div 10 = 0.14 \text{ cm} \quad 10.10 \div 2 = 5.05 \text{ cm}$$

$$V = 0.5 \times \pi \times (5.05)^2 \times 0.14 + 0.45 \times 10.10 \times 0.14 = \boxed{6.24 \text{ cm}^3}$$

- (ii) Show that the uncertainty in  $V$  is about  $0.2 \text{ cm}^3$ .

(4)

$$V = \frac{1}{8} \pi D^2 t + D x t$$

$$\frac{0.05}{10.10} \times 100 = 0.495\% \quad \frac{0.02}{1.4} \times 100 = 1.4\%$$

$$2 \times 0.495 + 1.4 = 2.42\% \quad 0.242 \times 0.25 \times 10.10^2 =$$

$$0.0242 \times 0.5 \times \pi \times (5.05)^2 \times 0.14 = 0.136$$

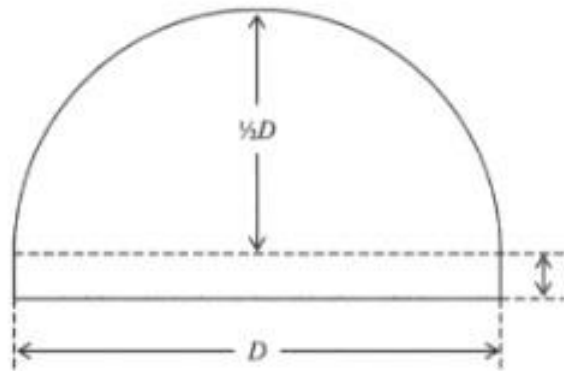
$$0.0242 \times \frac{1}{8} \times \pi \times (10.10)^2 \times 0.14 = 0.136 \quad \frac{0.1}{4.5} \times 100 = 2.22\%$$

$$2.22 + 1.4 + 0.495 = 4.15\% \quad 0.0415 \times 0.45 \times 10.10 \times 0.14 = 0.02638$$

$$0.02638 + 0.136 = \boxed{0.16 \text{ cm}^3}$$

# WPH16, Q4b – example 2

(b) The student determined the volume  $V$  of the plastic protractor from the measurements shown.



The student recorded the following measurements.

$$D = 10.10 \text{ cm} \pm 0.05 \text{ cm}$$

$$x = 4.5 \text{ mm} \pm 0.1 \text{ mm}$$

$$t = 1.40 \text{ mm} \pm 0.02 \text{ mm}$$

(i) Show that  $V$  is about  $6.2 \text{ cm}^3$ .

$$A = \pi r^2 = \pi \times (5.05)^2 \times 0.5 = 40.06 \text{ cm}^2$$

$$A = D \times x = 10.1 \text{ cm} \times 0.45 \text{ cm} = 4.545 \text{ cm}^2$$

$$V = 44.605 \text{ cm}^2 \times 0.14 \text{ cm} = 6.2447 = 6.2 \text{ cm}^3$$

lower limit =  $6.09 \text{ cm}^3$

$$A = 44.122 \text{ cm}^2$$

$$\pi r^2 = 39.7 \text{ cm}^2$$

$$Dx = 4.422 \text{ cm}^2$$

$$10.05$$

$$0.44$$

(ii) Show that the uncertainty in  $V$  is about  $0.2 \text{ cm}^3$ .

(4)

$$\text{upper limit} = 10.15 \text{ cm} \pm 0.142 \text{ cm} \pm 0.46 \text{ cm}$$

$$\frac{1}{2} \pi r^2 = 40.5 \quad Dx = 4.669 \quad A = 45.169 \text{ cm}^2$$

$$45.169 \text{ cm}^2 \times 0.46 \text{ cm} = 6.414 \text{ cm}^3$$

$$\text{lower limit} = 10.05 \text{ cm} \pm 0.138 \text{ cm} \quad \text{uncertainty} = 0.16 \text{ cm}^3$$

$$\frac{1}{2} \pi r^2 = 39.7 \text{ cm}^2 \quad Dx = 4.422 \text{ cm}^2 \quad A = 44.122 \text{ cm}^2$$

$$44.122 \text{ cm}^2 \times 0.138 \text{ cm} = 6.09 \text{ cm}^3 \quad \frac{6.414 - 6.09}{2} = 0.16 \text{ cm}^3$$

2

# Common mistakes (and how to avoid them)



# Common mistakes

1. When answering an AO2b question candidates sometimes forget to make a conclusion.
2. Some candidates do not pay sufficient attention to the command words used in the question.
3. Some candidates miss out on a final answer mark in a question because they omit units.
4. Some responses just repeat previous mark scheme answers.
5. The conclusion must include a comparison of the calculated answer and a value given in the question.
6. Candidates should learn the difference between 'describe' and 'explain' so the correct level of detail is included.
7. Units are required for all calculated final answers (including AO3 questions) unless it is a 'show that' question.
8. A 'standard' answer (as seen in a previous MS) is only fine if it is given in response to a standard question.



# Common mistakes

9. Some responses to unstructured calculations are poorly set out.
10. If candidates set their work out haphazardly, they may miss out on full marks for their response as it may not be clear what method they have used.
11. Definition and derivation questions are often poorly answered.
12. Linkage questions tend to miss out on essential detail required for indicative content credit to be given.
13. Candidates should set out their work so that the logic of the solution can be seen. It may help to divide the answer space into two columns so that candidates do not run out of space.
14. Candidates should be encouraged to learn standard definitions and derivations.
15. Candidates should be encouraged to plan the key points that they want to make before they start to write in the answer space.





# Support and resources

# Further Information

## Onscreen Assessment

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# Questions



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