Delegate Booklet

Pearson IAL Physics: Exam Insights June 2024

YPH11-24IO10

About this event

Course Title:
Pearson IAL Physics: Exam Insights June 2024

Course Code: YPH11-24IO10

Aims and Objectives of the event

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

Session Agenda

Item	Time
Introduction	3 min
Detailed analysis of questions:	
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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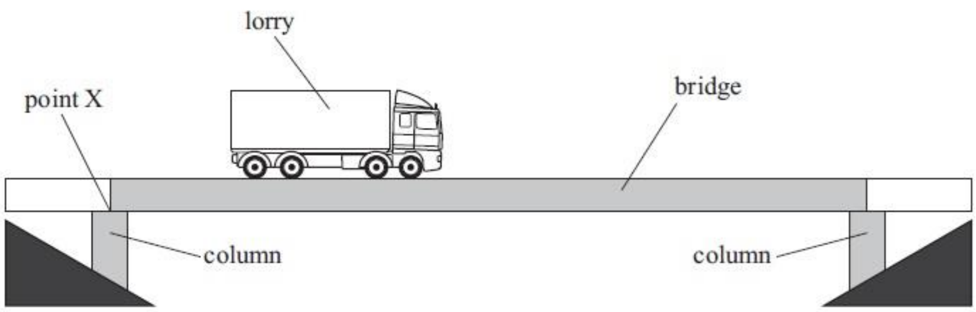
Feedback strand 1: unstructured calculations

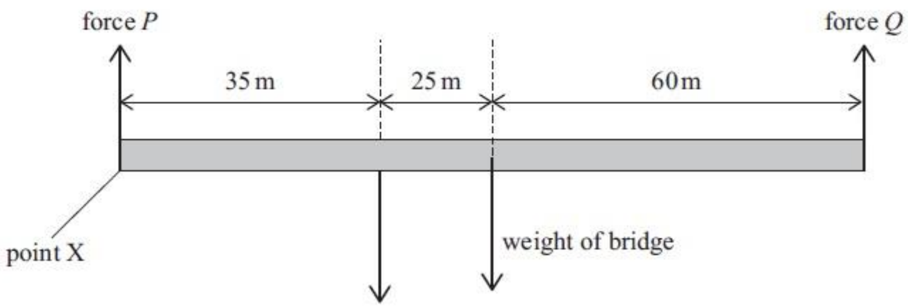
WPH11, Q18a

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.



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

You should take moments about point X.

force from lorry = 4.2×10^5 N
weight of bridge = 9.8×10^5 N

(5)

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

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Example 1

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

You should take moments about point X.

force from lorry = 4.2×10^5 N
weight of bridge = 9.8×10^5 N

(5)

unit: moment

the clockwise ~~momentum~~ moment is $60m \times 9.8 \times 10^5 N + 4.2 \times 10^5 N \times 85m$

$= ~~945\times~~ 9.45 \times 10^7 N \cdot m.$

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

$\Rightarrow P = 7.875 \times 10^5 N$

The clockwise moment is $35m \times 4.2 \times 10^5 N + (25m+30m) ~~25m~~ \times 9.8 \times 10^5 N$

$= 7.35 \times 10^7 N \cdot m$

The force $Q = \dfrac{~~force~~ \text{ moment}}{(35m + 25m + 60m)}$

$= 6.125 \times 10^5 N$

$P = 7.875 \times 10^5 N$

$Q = 6.125 \times 10^5 N.$

Example 2

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

You should take moments about point X.

force from lorry = 4.2×10^5 N
weight of bridge = 9.8×10^5 N

(5)

⇒ For force P

$F_1 d_1 = F_2 d_2$

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

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

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

⇒ For force Q

$F_1 d_1 = F_2 d_2$

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

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

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

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

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

$= 4.88 \times 10^5 N$

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

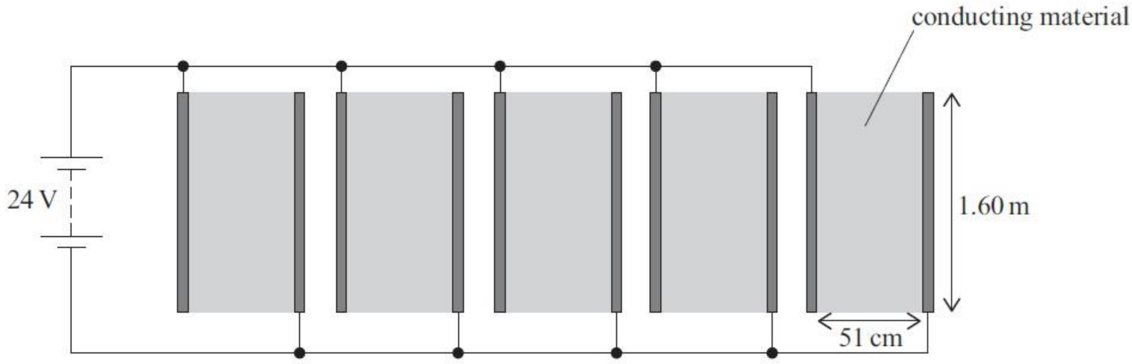
$= 7.51 \times 10^4 N$

$P = 4.9 \times 10^5 N$

$Q = 7.5 \times 10^4 N$

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)

14(d)	Calculate area using 1.60 × thickness	(1)	
	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)	
	OR		
	Calculate area using 1.60 × 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)	**5**
	<u>Example of calculation</u> $A = 1.60\text{ m} \times 0.48 \times 10^{-3}\text{ m} = 7.68 \times 10^{-4}\text{ m}^2$ $R = \frac{6.4 \times 10^{-3}\,\Omega\text{ m} \times 0.51\text{ m}}{7.68 \times 10^{-4}\text{ m}^2} = 4.25\,\Omega$ $R_{\text{total}} = \frac{4.25\,\Omega}{5} = 0.85\,\Omega$ $P = \frac{(24\text{ V})^2}{0.85\,\Omega} = 678\text{ W}$		

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)

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

$R = \frac{6.4 \times 10^{-3} (1.60)}{4.8 \times 10^{-4} (\frac{51}{100})}$

$R = 41.63\,\Omega$

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

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

$P = 68.9\,W$

Yes so the heating system is safe.

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)

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

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

~~$R = 26.44$~~

~~$P = \frac{V^2}{R}$~~ ~~$P = \frac{24^2}{26.44}$~~

51 cm → 0.51

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

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

$R = 0.85\,\Omega$

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

$P = \frac{24^2}{0.85}$

$P = 677.6\,W$

the student heating system is not safe

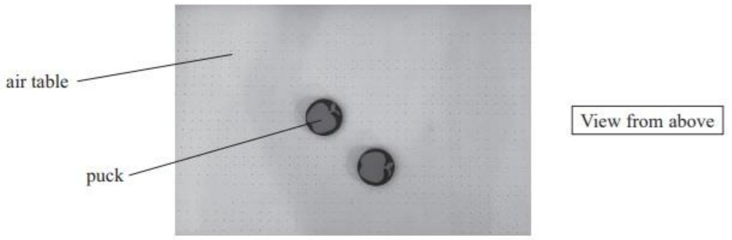
677.6 > 350 w

(Total for Question 14 = 14 marks)

WPH14, 15 bi

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.

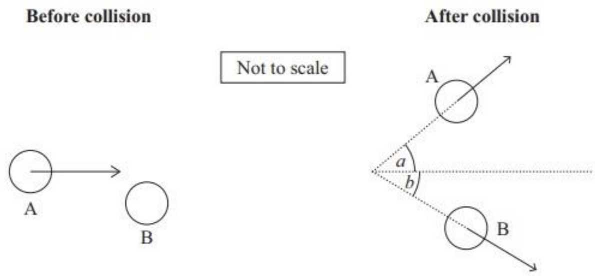


Some students used the air table to investigate conservation of momentum.

(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° 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 kg m s^{-1}
angle a	33°
final momentum of A	0.039 kg m s^{-1}

(i) Deduce whether the angle between the paths of the pucks after the collision was 90°.

You should use the principle of conservation of momentum.

(5)

15(b)(i)	Use of trigonometrical function for x component of A momentum after collision **Or** Use of trigonometrical function for y component of A momentum after collision Applies conservation of momentum Applies trigonometry to calculate final angle for B Angle between A and B = 91(°) Comparison between calculated angle and 90° including conclusion in words <u>Example of calculation</u> x component of A after = 0.039 kg m s^{-1} × cos 33° = 0.0327 kg m s^{-1} y component of A after = 0.039 kg m s^{-1} × sin 33° = 0.0212 kg m s^{-1} x component of B after = 0.046 kg m s^{-1} – 0.0327 kg m s^{-1} = 0.0133 kg m s^{-1} y component of B after = 0.0212 kg m s^{-1} tan θ = 0.0212 kg m s^{-1} ÷ 0.0133 kg m s^{-1} = 1.59 θ = 57.9° 58° + 33° = 91° which is about 90°	(1) (1) (1) (1) (1)	5

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Example 1

(i) Deduce whether the angle between the paths of the pucks after the collision was 90°.

You should use the principle of conservation of momentum.

(5)

Horizontally (⟷)

$P_{Ab} = mv = 0.046 \, kgms^{-1}$

~~0.046~~

$P_{AaH} = P_{Aa} \cdot \cos a$

$= 0.039 \cdot \cos 33°$

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

$P_{Ab} - P_{AaH} = P_{BaH} = 0.013 \, kgms^{-1}$

Vertically (↕)

$P_{AaV} = P_{Aa} \cdot \sin a$

$= 0.039 \cdot \sin 33°$

$P_{AaV} = 0.021 \, kgms^{-1}$

$P_{BaV} = P_{AaV} = 0.021 \, kgms^{-1}$

$P_{Ba}^2 = P_{BaV}^2 + P_{BaH}^2$

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

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

$\tan b = \frac{P_{BaV}}{P_{BaH}} = \frac{0.025}{0.013}$

$\tan b = 1.923$

$b = 62.5°$

$a + b = 95.5°$

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

Example 2

(i) Deduce whether the angle between the paths of the pucks after the collision was 90°.

You should use the principle of conservation of momentum.

(5)

$0.039 \times \cos 33° = 0.0327$ ~~ms~~ $kgms^{-1}$

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

$0.039 \times \sin 33° = 0.0212 \, kgms^{-1}$

~~$\tan^{-1}\left(\frac{0.012}{0.0133}\right) = 86.4°$~~

~~$86.4 < 90°$~~

$\sqrt{0.0133^2 + 0.0212^2} = 0.025 \, kgms^{-1}$

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

$57.9° + 33° = 90.9°$

$90.9°$ ~~≈ 90°~~

WPH15, Q15b

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 3.53×10^5 kg.

Show that the energy required to melt this ice floe is about 1.3×10^{11} 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 m
volume of ice floe = $385\,\text{m}^3$
1 day = 8.64×10^4 s

(6)

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

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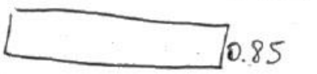
Example 1

(b) At the top of the atmosphere, the intensity of radiation from the Sun is 1370 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 m
volume of ice floe = 385 m^3
1 day = 8.64 × 10^4 s

(6)

$I = 1370 \cdot (1-0.44) = 767\ W\,m^{-2}$

$A = \frac{380}{0.85} = 447, m^2$

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

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

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

∴ The claim is wrong as the ice melts in 4.45 days

(Total for Question 15 = 9 marks)

Example 2

(b) At the top of the atmosphere, the intensity of radiation from the Sun is 1370 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 m^3
1 day = 8.64 × 10^4 s

(6)

Area $= \frac{385}{0.85} =$ ~~453m~~ $453 m^2$

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

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

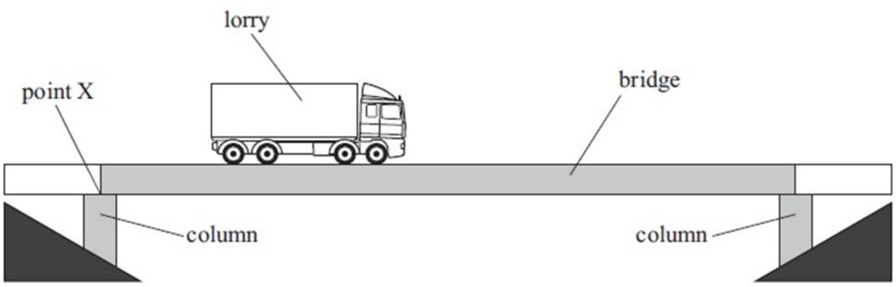
$1.65 \times 10^{11} J > 1.32 \times 10^{11} J$

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

Feedback strand 3: explanation questions

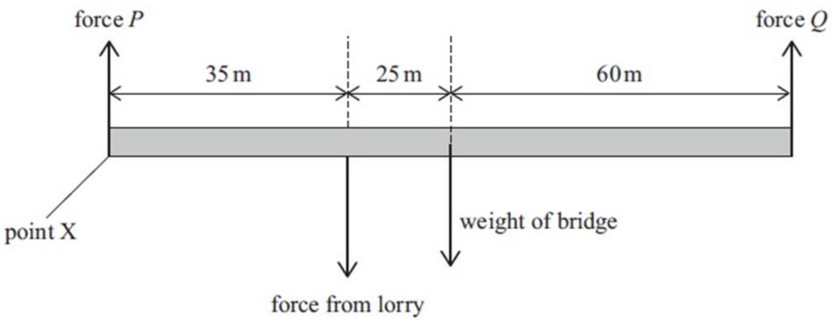
WPH11, Q16c

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)

18(b)	Allow P for X throughout Allow Q for Y throughout		
	EITHER		
	Distance from X to (centre of gravity of) lorry increases	**(1)**	
	(So) moment (about X) due to (force from) lorry increases	**(1)**	
	Sum of moments remains zero (for equilibrium)	**(1)**	
	So moment (about X) due to Q increases	**(1)**	
	Distance from X to Q remains the same therefore Q increases	**(1)**	
	OR		
	Distance from other end of bridge (Y) to (centre of gravity of) lorry decreases	**(1)**	
	(So) moment about Y due to (force from) lorry decreases	**(1)**	
	Sum of moments remains zero (for equilibrium)	**(1)**	
	So moment about Y due to P decreases, and P must decrease	**(1)**	
	And (at equilibrium) the sum of P and Q remains the same therefore Q increases	**(1)**	**5**

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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 ∴ weight is not evenly distributed. The lorry would be causing a 'turning force" clockwise which Force Q, the collum 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, and any other point of the bridge ∵ since M = Fd, the further away the lorry gets the greater the turning force produced. This resultant force needs to be countered.

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 = $F_Q \times 120$

Since it is in equilibrium, the resultant moment is zero

$120 F_Q$ ~~$= W_L x + 60W$~~ $= W_L x + 60W$

Then when x increases, F_Q would increase.

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WPH15, Q18bii

(b) Luminosity measurements suggest that our galaxy has a mass equal to 8.0×10^{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 5.7×10^{20} m from the centre of the galaxy.

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

(ii) The orbital period of the star is actually 6.0×10^{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)

18(b)(ii)	The actual period is (much) smaller than the calculated value	**(1)**	
	So the mass of the galaxy must be greater than 8.0×10^{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)**	**4**

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Example 1

(ii) The orbital period of the star is actually 6.0×10^7 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. ∴ this tells that our galaxy contains dark matter which we can't detect which means we won't know its actual mass from its Luminosity.

Example 2

(ii) The orbital period of the star is actually 6.0×10^7 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 ($v \propto \frac{1}{T}$). 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

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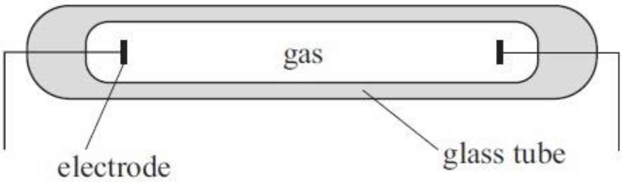
Feedback strand 4: linkage questions

WPH12, Q17aii

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.

(6)

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

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

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 ~~in~~ is higher. The release of ~~electrons~~ ~~photons~~ photoelectrons from an atom is instantaneous. So when the intensity increases, the ~~rate~~ rate of ~~photon~~ photoelectrons released ~~increases~~ increases as ~~one~~ 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 varry. ~~Th~~ 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.

Example 2

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

(6)

gas atoms absorb ~~photons~~ electrons. since $E = VQ$ larger the potential difference more the energy. when the energy of the ~~photon~~ electron is greater

$E = hf = \phi + \frac{1}{2}mv^2$ the electrons gain energy and move to a higher energy level where they are exited. when the electrons get de-exited they move to lower energy level emitting a photon. energy levels are discreet and the difference in energy levels is the energy of the photon. energy is directly proportional to the frequeny. electrons require minium threshold frequency to be emitted.

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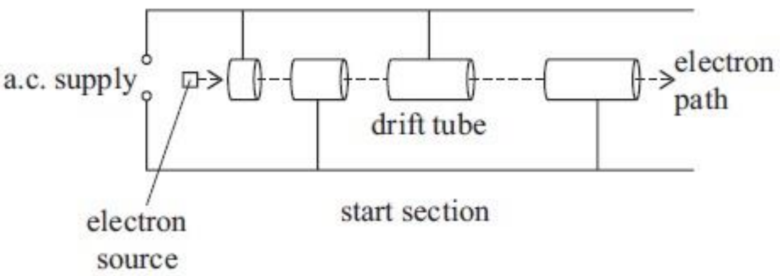
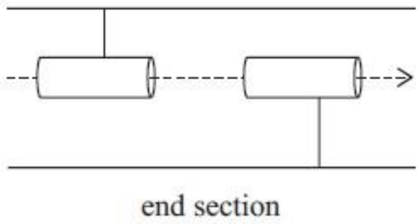
WPH14, 16b

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





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.

(6)

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3		1	3
2	2	0	2
1	1	0	1
0	0	0	0

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

Pearson

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 ~~in~~ is higher. The release of ~~electrons~~ ~~photons~~ photoelectrons from an atom is instantaneous. So when the intensity increases, the ~~rate~~ rate of ~~photon~~ photoelectrons released ~~increses~~ increases as one ~~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 varry. ~~Th~~ If this frequency is higher than the threshold frequency, then photonelectrons will be released ~~Photon~~ as ~~phot~~ the photon energy is relative to the frequency.

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 leavings 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.

Feedback strand 5: experimental skills
WPH13, 3b

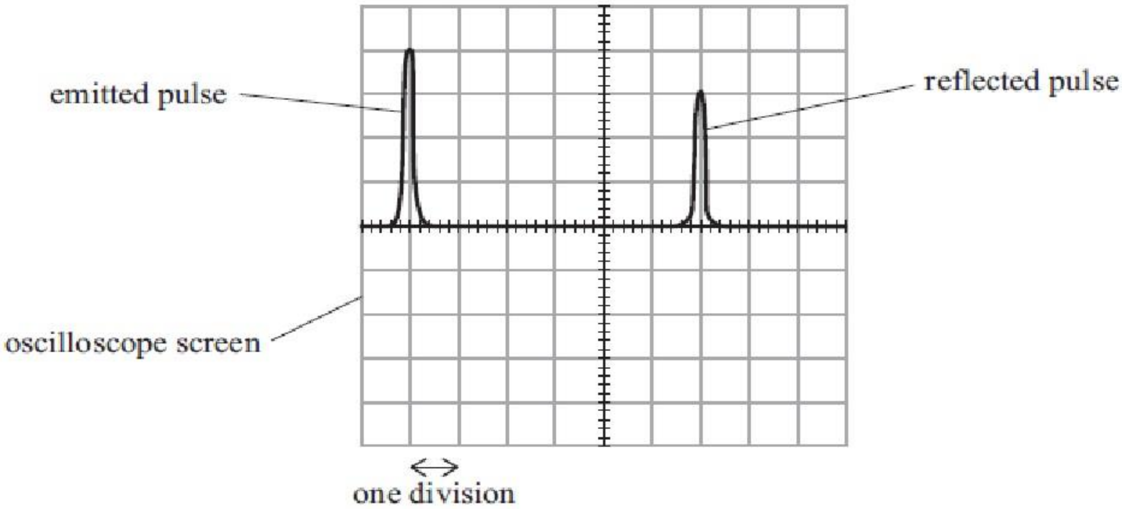
3 A student determined the speed of ultrasound in air using an ultrasound transducer.

(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 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 cm

3(b)	Calculates time t = number of divisions × time per division Use of $v = \frac{s}{t}$ Uses $2 \times s$ **Or** Uses $\frac{1}{2} \times t$ $v = 331$ (m s^{-1}) <u>Example of calculation</u> t = 6 divisions × 0.5 ms per division = 3 ms $v = \frac{s}{t} = \frac{2 \times 0.497\text{ m}}{3 \times 10^{-3}\text{ s}} = 331.3\text{ m s}^{-1}$	**(1)** **(1)** **(1)** **(1)**	**4**

Example 1

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

length of air column s = 49.7 cm

(4)

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

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

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

distance $= 2 \times S$ (in order to travel and be reflected back)

Example 2

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

length of air column s = 49.7 cm

(4)

~~0.5ms × 10 = 5ms~~ $\frac{49.7\,cm}{100} = 0.497\,m$ $\frac{0.5\,ms}{1000} = 5 \times 10^{-4}\,s$

$5 \times 10^{-4}\,s \times 10 = 5 \times 10^{-3}\,s$ $2s = 0.994\,m \therefore \frac{0.994}{2.5 \times 10^{-3}} = 397.6\,ms^{-1}$

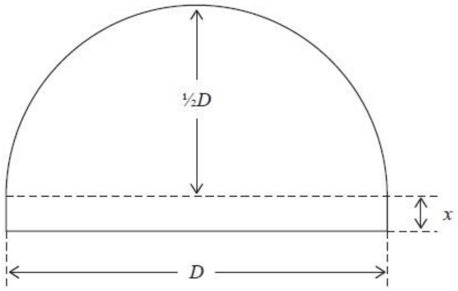
$5 \times 10^{-3} \times \frac{1}{2}$ since time should be halved since wave is reflected.

length is doubled since the wave is reflected.

Pearson

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 $0.2\,\text{cm}^3$.

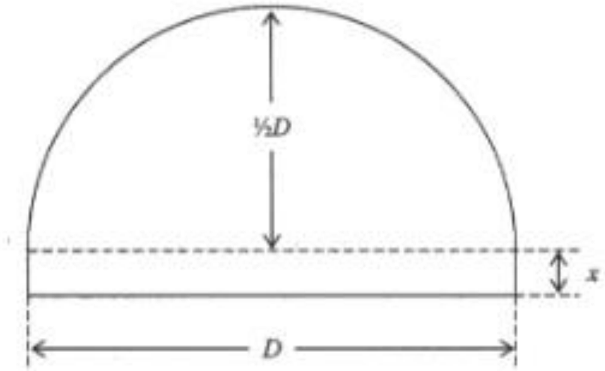
(4)

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

Pearson

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 cm³.

(2)

$4.5 \div 10 = 0.45\,\text{cm}$ $\quad 1.4 \div 10 = 0.14\,\text{cm}$ $\quad 10.10 \div 2 = 5.05\,\text{cm}$

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

(ii) Show that the uncertainty in V is about 0.2 cm³.

(4)

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

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

$2 \times 0.495 + 1.4 = 2.42\%$, ~~0.242×0.25×π×10.10²=~~

~~0.0242×0.5×π×(5.05)²×0.14 = 0.135~~

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

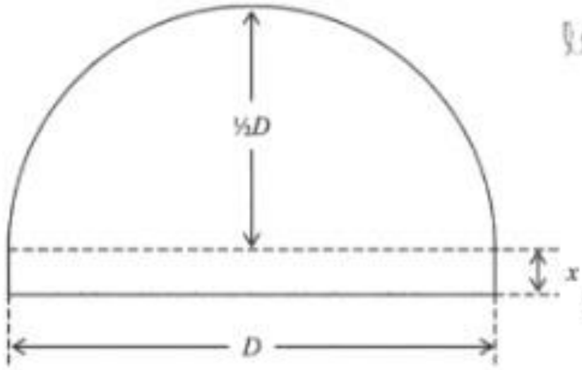
$2.22 + 1.4 + 0.495 = 4.15\%$. $\quad 0.0415 \times 0.45 \times 10.10 \times 0.14 = 0.02638$

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

Pearson

Example 2

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



lower limit = 6.09cm³

A = 44.122cm²

πr² 39.7cm²

Dx = 4.422cm²

0.158

10.05

0.44

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)

A = πr² = π × (5.05)² × 0.5 = 40.06cm² } 44.605 cm²
A = D × x = 10.1cm × 0.45cm = 4.545cm² }
V = 44.605cm² × 0.14cm = 6.2447 = 6.2cm³

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

(4)

upper limit = D: 10.15cm t: 0.142cm
x: 0.46cm
½πr² = 40.5   Dx = 4.669   A = 45.169cm²
45.169 cm² × 0.46cm = 6.414cm³
lower limit = D: 10.05cm t: 0.138cm   uncertainty = 0.16cm³
x: 0.44cm
½πr² = ~~44.122cm²~~ 39.7cm²   Dx = 4.422cm²   A = 44.122cm²
44.122cm² × 0.158cm = 6.09 cm³   (6.414 − 6.09) / 2 = 0.16cm³