Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

AS PHYSICS

Paper 2

Wednesday 21 May 2025 Afternoon

Time allowed: 1 hour 30 minutes
You are advised to spend about 35 minutes on Section C

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5–34	
TOTAL	

Materials

For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- a protractor.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 70.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

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Section A

Answer **all** questions in this section.

0 1 This question is about a method to investigate interference by a diffraction grating (required practical activity 2).

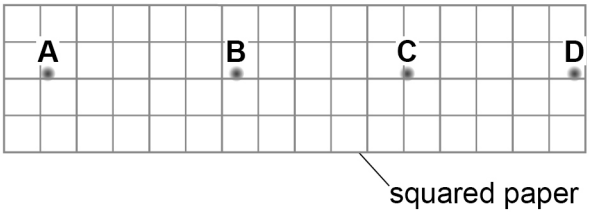
Light from a laser is shone onto the diffraction grating at normal incidence.

0 1 . 1 State **one** safety precaution when using a laser in a school laboratory.

[1 mark]

A piece of squared paper is positioned parallel to the diffraction grating.
Figure 1 shows the pattern of four bright spots **A**, **B**, **C** and **D** that are seen on the paper.

Figure 1



A student determines the distance x from the **left-hand** edge of the paper to the centre of each spot.
Table 1 shows these data, including the uncertainty in each value of x.

Table 1

Spot	x / mm
A	60 ± 5
B	321 ± 5
C	553 ± 5
D	785 ± 5

Do not write outside the box

0 1 . 2 **C** is the central maximum.

Determine Δx, the distance between **C** and the spot at the second-order maximum.
Go on to determine the percentage uncertainty in Δx.

[2 marks]

$\Delta x =$ _____ mm

percentage uncertainty = _____ %

0 1 . 3 When the readings in **Table 1** were taken, the distance between the grating and the paper was 1.20 m.
The grating has 300 lines per mm.

Determine an accurate value for the wavelength of the laser light.

[3 marks]

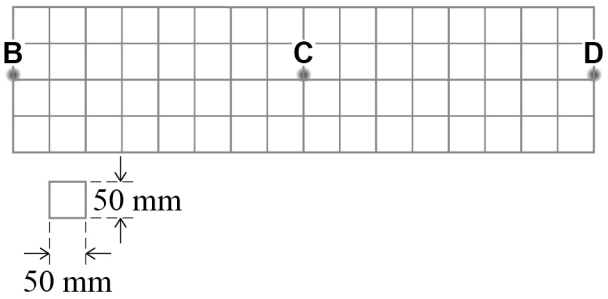
wavelength = _____ m

Question 1 continues on the next page

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0 1 . 4 The student changes the distance between the grating and the paper so that **B** and **D** are at the edges of the paper as shown in **Figure 2**.
The paper and diffraction grating remain parallel.

Figure 2



Determine the new distance between the grating and the paper.

[2 marks]

distance = _____ m

8

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

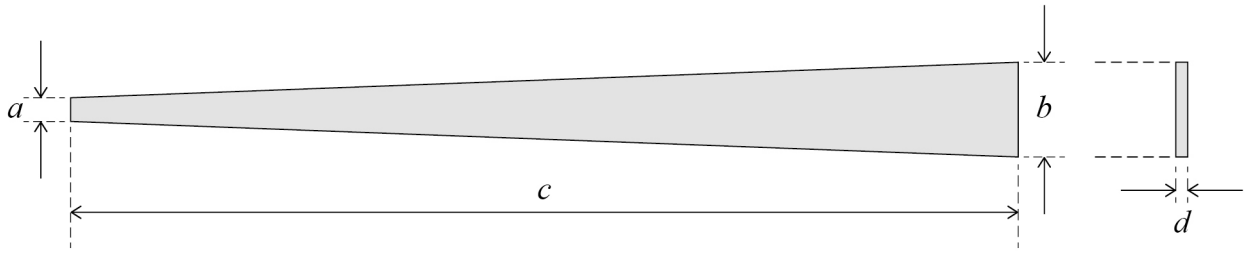
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0 2 This question is about a method to determine the centre of mass of a tapered metal beam.

Figure 3 shows the beam.
The width of the beam varies from a at its narrow end to b at its wide end.
The beam has a length c and a constant thickness d.

Figure 3

not to scale



view of one face **view of wide end**

0 2 . 1 **Table 2** shows the values of dimensions a, b, c and d measured by a student.
The resolution of the measuring instrument used determines the number of decimal places in the value.

Complete **Table 2** with the names of suitable instruments to measure b, c and d.
[1 mark]

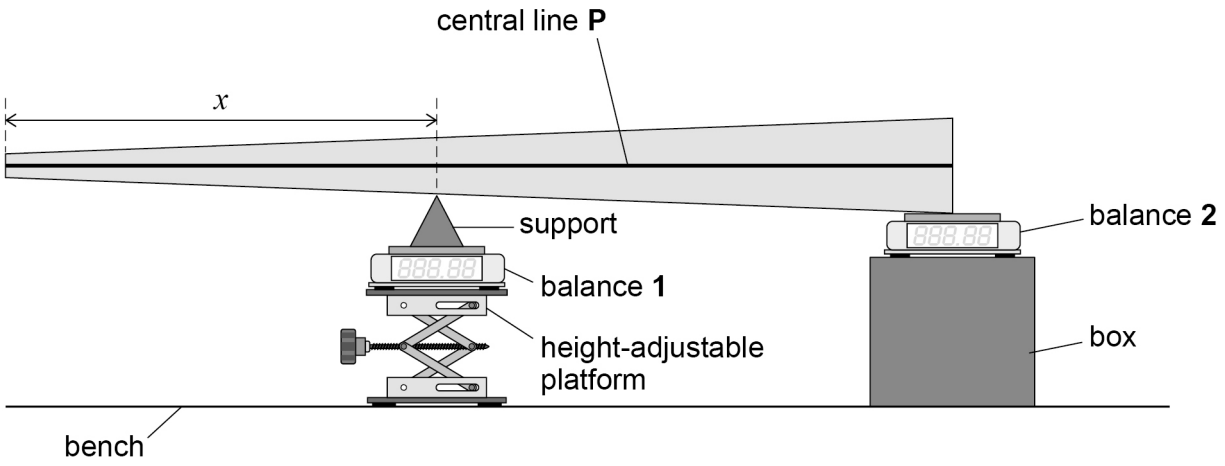
Table 2

Dimension	Value / mm	Instrument used
a	21.5	vernier calipers
b	86.0	
c	900	
d	9.74	

Do not write outside the box

The student draws a line **P** along the centre of one of the large faces. The centre of mass of the beam lies on line **P**.
Figure 4 shows apparatus used to locate the centre of mass.

Figure 4



The student sets up the apparatus on the bench as follows:

1. digital balance **1** is placed on the height-adjustable platform
2. digital balance **2** is placed on the box
3. the triangular support is placed on balance **1**
4. both balances are set to zero
5. the beam is placed in the position shown in **Figure 4**
6. the height of the platform is adjusted until line **P** is horizontal.

0 2 . 2 Describe how to use a metre ruler and a set square to check that line **P** is horizontal.
You may annotate **Figure 4**.

[2 marks]

Question 2 continues on the next page

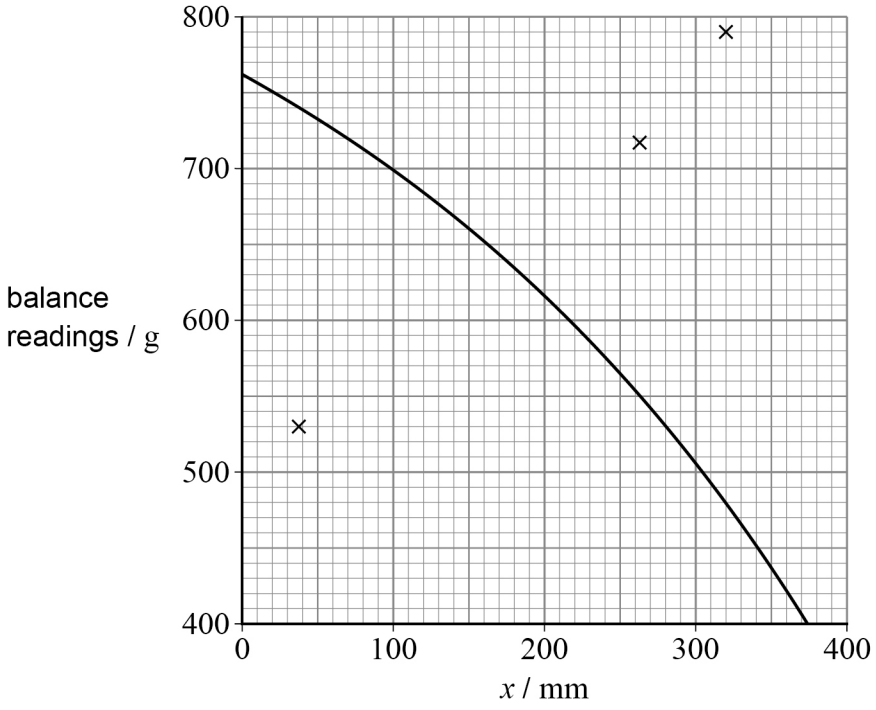
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The horizontal distance x from the narrow end of the beam to the support is measured.
The reading m_1 on balance **1** and the reading m_2 on balance **2** are recorded.

The platform, balance **1** and the support are then moved to change the value of x.
The height of the platform is adjusted so that line **P** is horizontal.
New readings of m_1, m_2 and x are recorded.
The procedure is repeated for different values of x.

Figure 5 shows some of the results.

Figure 5



The line shows the variation of m_2 with x.
The graph also shows three plotted values of m_1 for corresponding values of x.
Table 3 shows values of m_1 for two other values of x.

Table 3

x / mm	m_1 / g
130	594
205	658

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0 2 . 3 Plot, on **Figure 5**, the data in **Table 3**.
Go on to draw a line to show how m_1 varies with x.

[2 marks]

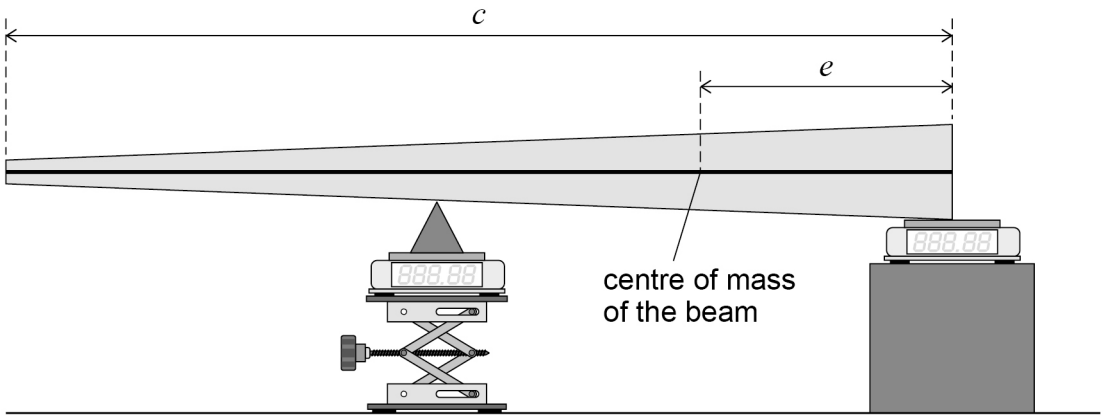
0 2 . 4 Determine an accurate value for the mass of the beam.

[2 marks]

mass of the beam = _____ g

The centre of mass of the beam is at a distance e from the wide end, as shown in **Figure 6**.

Figure 6



When $m_1 = m_2$, $2e$ is given by:

$$2e = c - x$$

0 2 . 5 Deduce a value for e using your completed **Figure 5**.

$c = 900$ mm

[2 marks]

e = _____ mm

Question 2 continues on the next page

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The numbered list below **Figure 4** shows the six steps involved in setting up the apparatus.

A second student sets both balances to zero **before** placing the support on balance **1**. This means that the second student has done steps **3** and **4** in the wrong order. The second student varies x to produce readings of m_1 and m_2. The student plots the variation of m_1 and m_2 with x.

0 2 . 6 Explain how the second student's graph of the variation of m_1 with x is different from the graph in **Figure 5**.

[1 mark]

0 2 . 7 The second student wrongly assumes that when their $m_1 = m_2$, $2e$ is given by:

$$2e = c - x$$

The second student goes on to determine their value of e.

State and explain how the second student's value of e compares with the correct value.

[2 marks]

12

END OF SECTION A

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Turn over for Section B

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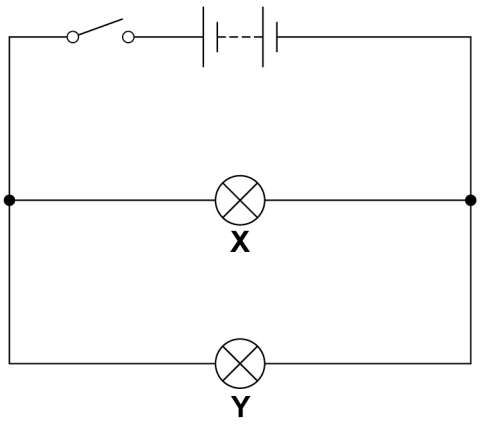
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Section B

Answer **all** questions in this section.

0 3 **Figure 7** shows a circuit for car headlamps **X** and **Y**.

Figure 7



The battery has an emf of $12\ \text{V}$ and an internal resistance of $0.037\ \Omega$.

When the switch is closed, each lamp operates at a power of $65\ \text{W}$.
The current in the battery is I.

0 3 . 1 For this circuit, it can be shown that:

$$12I = 0.037I^2 + 130$$

Explain, using conservation of energy, why this equation is valid.

[2 marks]

Do not write outside the box

0 3 . 2 Show that I is approximately 11 A.

[2 marks]

0 3 . 3 Determine the resistance of **X** when it operates at a power of 65 W.

[2 marks]

resistance of **X** = _____ Ω

0 3 . 4 The diameter of the filament of **X** decreases during use. This changes the resistance of **X**.
The resistance of **Y** does not change.
The emf and the internal resistance of the battery also do not change.

Deduce whether **Y** continues to operate at a power of 65 W.

[4 marks]

10

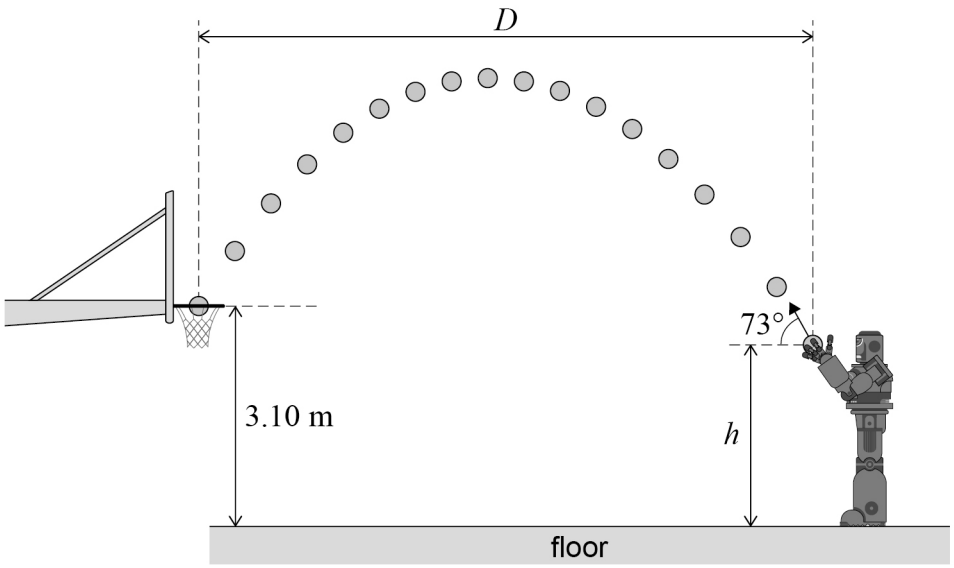
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0 4 **Figure 8** shows a series of time-lapse images of a basketball thrown by a robot. Images are taken at constant time intervals.

Figure 8

not to scale



The robot throws the ball from a height h above the floor and at an angle of $73°$ to the horizontal.
The vertical component of the initial velocity of the ball is $8.7\ \text{m s}^{-1}$.
The horizontal distance between the first image and the last image is D.
The time of flight for distance D is $1.7\ \text{s}$.
Assume that air resistance is negligible.

0 4 . 1 Determine D.

[2 marks]

$D =$ _____ m

Do not write outside the box

0 4 . 2 The vertical displacement of the ball from the floor in the last image is $3.10\ \text{m}$.

Determine h.

[3 marks]

$h =$ _____ m

0 4 . 3 The ball is again thrown by the robot.
The initial speed of the ball is the same as in **Figure 8**.
The angle for this throw is less than $73°$.

Another set of images is taken as the ball moves through the same horizontal distance D.
The constant time interval between each image is unchanged.

Deduce whether the number of images of the ball is different from the number in **Figure 8**.

[2 marks]

Question 4 continues on the next page

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0 4 . 4 When air resistance is significant, the magnitude of the vertical component a_v of the acceleration of the ball varies throughout the flight.

Discuss how air resistance affects a_v when the vertical displacement of the ball is:

- increasing
- decreasing.

[3 marks]

10

END OF SECTION B

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Section C

Each of Questions **05** to **34** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question, completely fill in the circle alongside the appropriate answer.

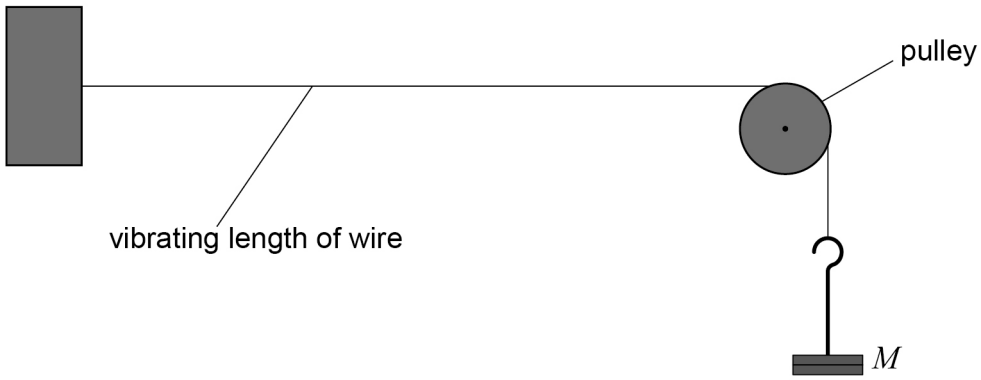
CORRECT METHOD ⬬ WRONG METHODS ⊗ ⦿ ≈ ⊘

If you want to change your answer you must cross out your original answer as shown. ⊠

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. ⊗

You may do your working in the blank space around each question but this will not be marked.
Do **not** use additional sheets for this working.

0 5 A horizontal length of wire vibrates between a fixed point and a frictionless pulley.
The tension in the wire is caused by the weight of a mass M.
The frequency of the first harmonic of the vibrating wire is 420 Hz.



An additional mass of $2M$ is added to M to increase the tension.
No other change is made.

What is the new frequency of the first harmonic of the wire?

[1 mark]

A 210 Hz ⬭

B 590 Hz ⬭

C 730 Hz ⬭

D 840 Hz ⬭

Turn over ►

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0 6 An electron and a proton have the same de Broglie wavelength.

What is $\frac{\text{speed of the electron}}{\text{speed of the proton}}$ to an order of magnitude?

[1 mark]

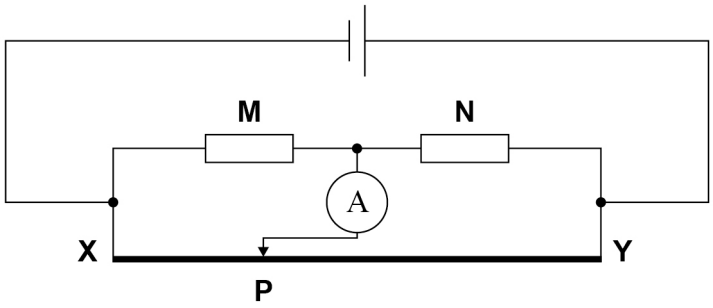
A 10^{-3} ⬭

B 10^{-2} ⬭

C 10^{1} ⬭

D 10^{3} ⬭

0 7 A long uniform metal wire **XY** is connected in parallel to two resistors **M** and **N** as shown.



An ammeter connects the wire between **M** and **N** to a point **P** on **XY**.
The reading on the ammeter is zero.

A change is then made to the circuit. After the change, the ammeter connection on **XY** has to be moved from **P** towards **X** so that the ammeter again reads zero.

What change was made to the circuit?

[1 mark]

A **N** was replaced with a resistor of greater resistance. ⬭

B **XY** was replaced with a wire of greater resistance. ⬭

C The cell was replaced with one of greater emf. ⬭

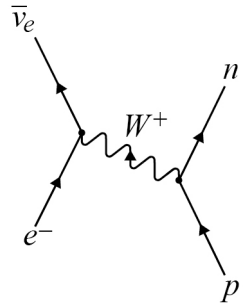
D The cell was replaced with one of greater internal resistance. ⬭

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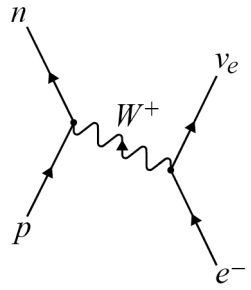
0 8 Which diagram represents an electron–proton collision?

[1 mark]

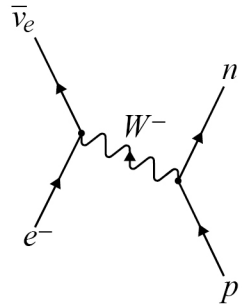
A



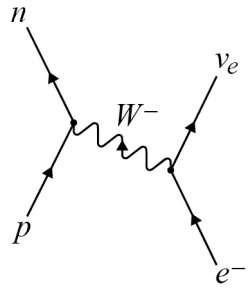
B



C



D



Turn over for the next question

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0 9 The minimum distance between two points on a progressive wave with a phase difference of $\frac{\pi}{2}$ is 0.040 m.

The frequency of the wave is 400 Hz.

What is the speed of the wave?

[1 mark]

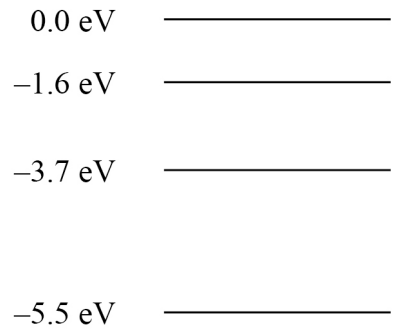
A $16\ \text{m s}^{-1}$ ⬭

B $32\ \text{m s}^{-1}$ ⬭

C $64\ \text{m s}^{-1}$ ⬭

D $128\ \text{m s}^{-1}$ ⬭

1 0 The diagram shows some of the excited energy levels of an atom.
The ground state is **not** shown.



When an electron falls from the -1.6 eV energy level to the ground state, a photon of frequency 2.1×10^{15} Hz is emitted.

What is the frequency of the photon emitted when an electron falls from the -3.7 eV energy level to the ground state?

[1 mark]

A 4.3×10^{14} Hz ⬭

B 8.9×10^{14} Hz ⬭

C 1.2×10^{15} Hz ⬭

D 1.6×10^{15} Hz ⬭

Do not write outside the box

1 1 Two coherent sources generate sound waves of wavelength $0.40\ \text{m}$.
The waves are in phase when they leave the sources.
The path difference between a detector and each of the two sources is $2.0\ \text{m}$.

What is the phase difference between the waves arriving at the detector?

[1 mark]

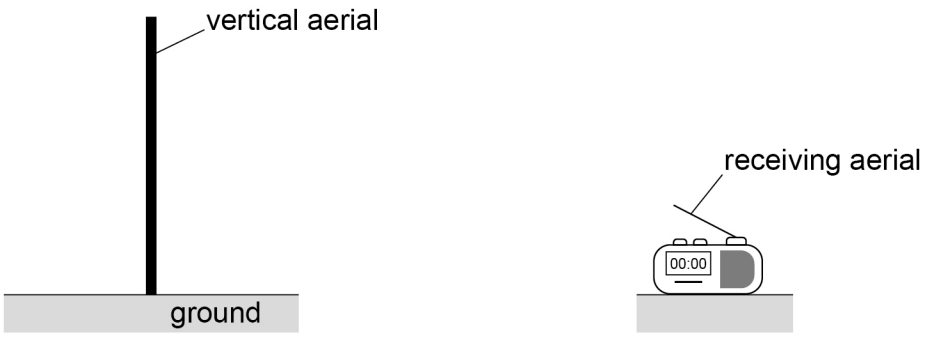
A zero ⬭

B $45°$ ⬭

C $90°$ ⬭

D $180°$ ⬭

1 2 Radio waves are transmitted from a vertical aerial and detected by a receiving aerial.
The alignment of the receiving aerial can be varied.



Which row shows the nature of the transmitted radio wave and the alignment of the receiving aerial that is needed in order to detect a maximum signal?

[1 mark]

	Nature of transmitted radio wave	**Alignment of receiving aerial**	
A	polarised	vertical	⬭
B	polarised	horizontal	⬭
C	unpolarised	vertical	⬭
D	unpolarised	horizontal	⬭

Turn over ►

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1 3 Two skydivers **X** and **Y** step out of a stationary hot-air balloon at the same time.
Both skydivers reach terminal speed.

mass of **X** = 120 kg
mass of **Y** = 90 kg

Which row is correct?

[1 mark]

	Time to reach terminal speed	Upward force at terminal speed	
A	time for **X** < time for **Y**	upward force on **X** > upward force on **Y**	⬭
B	time for **X** = time for **Y**	upward force on **X** = upward force on **Y**	⬭
C	time for **X** > time for **Y**	upward force on **X** = upward force on **Y**	⬭
D	time for **X** > time for **Y**	upward force on **X** > upward force on **Y**	⬭

1 4 Monochromatic light passes from air to glass.
The light has a wavelength of 632 nm in air.
The refractive index of the glass is 1.50

What is the wavelength of the light in the glass?

[1 mark]

A 316 nm ⬭

B 421 nm ⬭

C 632 nm ⬭

D 948 nm ⬭

Do not write outside the box

1 5 A cylindrical beaker contains water. The diameter of the water surface is $200\ \text{mm}$.

A pencil is dipped into the centre of the surface at time $t = 0$
A circular wave travels outwards on the surface from the pencil.

The speed of the wave on the surface is $150\ \text{mm s}^{-1}$.

Which row shows the radius of the wave and the direction of travel of the wave when $t = 1.0\ \text{s}$?

[1 mark]

	Radius of wave / mm	**Direction of travel**	
A	50	towards centre	⬭
B	50	away from centre	⬭
C	150	towards centre	⬭
D	150	away from centre	⬭

1 6 A string vibrates at the Nth harmonic.
The separation x between adjacent nodes is $0.60\ \text{m}$.

The string now vibrates at the $(N + 1)$th harmonic and x decreases by $0.12\ \text{m}$.

What is N?

[1 mark]

A 3 ⬭

B 4 ⬭

C 5 ⬭

D 6 ⬭

Do not write outside the box

1 7 Which is **not** equivalent to the newton?

[1 mark]

A $\mathrm{J\ m^{-1}}$ ⬭

B $\mathrm{kg\ m\ s^{-2}}$ ⬭

C $\mathrm{W\ s^{-2}}$ ⬭

D $\mathrm{W\ s\ m^{-1}}$ ⬭

1 8 The characteristics of four electrical components **A**, **B**, **C** and **D** are shown in the table.

The table shows values of potential difference V across each component and the corresponding values of current I in each component.

	A	**B**	**C**	**D**
V / V	I / A	I / A	I / A	I / A
0.0	0.0	0.0	0.0	0.0
2.0	0.3	1.5	0.6	0.0
4.0	0.6	2.3	1.2	0.2
6.0	0.9	2.7	1.8	1.2
8.0	1.2	3.1	2.4	2.2
10.0	1.5	3.3	3.0	3.2

Which is the ohmic conductor that has the smallest resistance?

[1 mark]

A ⬭

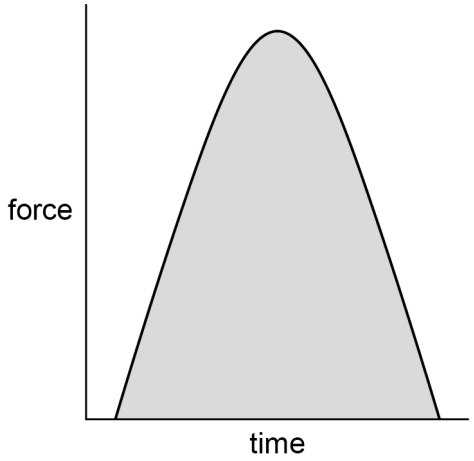
B ⬭

C ⬭

D ⬭

Do not write outside the box

1 9 The graph shows how the force acting on an object varied with time.



The shaded area represents:

[1 mark]

A the change in kinetic energy of the object. ⬭

B the change in momentum of the object. ⬭

C the distance travelled by the object. ⬭

D the total force that acted on the object. ⬭

2 0 An object falls from rest. Air resistance is negligible.
When the object has fallen through a distance x, its velocity is v.

How does v vary with x?

[1 mark]

A $v \propto \sqrt{x}$ ⬭

B $v \propto \frac{1}{x}$ ⬭

C $v \propto x^2$ ⬭

D $v \propto \frac{1}{x^2}$ ⬭

Do not write outside the box

2 1 **P** and **Q** are wires made from the same material.
The length of **Q** is double the length of **P**.
The diameter of **Q** is double the diameter of **P**.
P and **Q** are joined.

One end of **P** is held firmly and a force F is applied to **Q** as shown.



$$X_{\mathrm{P}} = \frac{\text{stress in } \mathbf{P}}{\text{strain of } \mathbf{P}}$$

$$X_{\mathrm{Q}} = \frac{\text{stress in } \mathbf{Q}}{\text{strain of } \mathbf{Q}}$$

X_{Q} is equal to:

[1 mark]

A $\frac{X_{\mathrm{P}}}{4}$ ⬭

B X_{P} ⬭

C $2X_{\mathrm{P}}$ ⬭

D $4X_{\mathrm{P}}$ ⬭

2 2 Which is **not** true for longitudinal waves?

[1 mark]

A They can be polarised. ⬭

B They produce interference patterns. ⬭

C They can be diffracted. ⬭

D They form stationary waves. ⬭

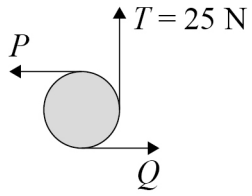
Do not write outside the box

2 3 A uniform disc of weight $50\ \text{N}$ is suspended by the tension T in a thread.
Two horizontal forces P and Q form a couple, where P and Q are both $25\ \text{N}$.
P, Q and T are tangential to the rim of the disc.

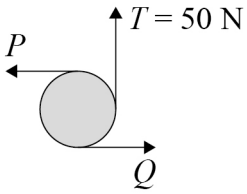
Which diagram shows the system in equilibrium?

[1 mark]

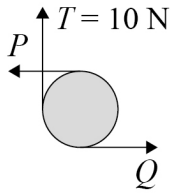
A



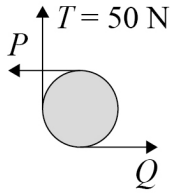
B



C



D



Turn over for the next question

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2 4 A rod is made of a metal of Young modulus E.
When the rod is unstretched, it has a cross-sectional area A and a length L.
A force is then applied to the rod that produces an extension x.
The rod obeys Hooke's law.

What is the elastic strain energy stored in the rod?

[1 mark]

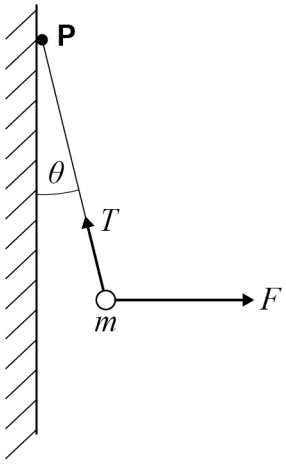
A $\frac{Ax}{2EL}$ ⬭

B $\frac{AEx}{2L}$ ⬭

C $\frac{Ax^2}{2EL}$ ⬭

D $\frac{AEx^2}{2L}$ ⬭

2 5 A mass m is suspended from a point **P** by a light string.
A force F acts horizontally on m so that the string makes an angle θ to the vertical position.
The system is in equilibrium.



What is correct for this system?

[1 mark]

A $F = T\cos\theta$ ⬭

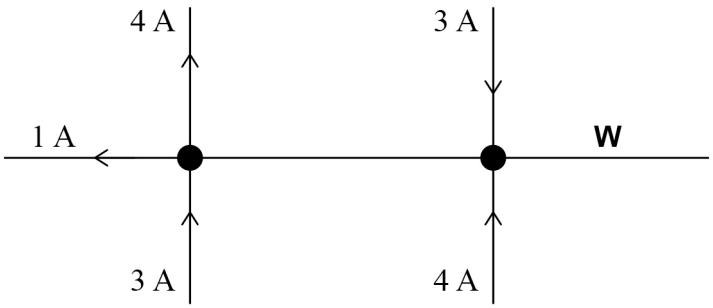
B $(mg)^2 = T^2 + F^2$ ⬭

C $mg = T\sin\theta$ ⬭

D $mg\sin\theta = F\cos\theta$ ⬭

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2 6 The diagram shows the currents in a set of wires.



What is the current in wire **W**?

[1 mark]

A 1 A ⬭

B 2 A ⬭

C 5 A ⬭

D 7 A ⬭

2 7 The resistivity of the metal used in a uniform wire is determined from a set of measurements.
The percentage uncertainties in the measurements are shown below.

Measurement	Percentage uncertainty
current in wire	0.1%
diameter of wire	3.0%
length of wire	0.5%
potential difference across wire	0.2%

What is the percentage uncertainty in the calculated value for the resistivity of the metal?

[1 mark]

A 3.8% ⬭

B 6.8% ⬭

C 9.8% ⬭

D 10.3% ⬭

Turn over ►

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2 8 What is the number of down quarks and the number of up quarks in a nucleus of $^{19}_{9}\mathrm{F}$?

[1 mark]

	Number of down quarks	Number of up quarks	
A	28	29	⬭
B	29	28	⬭
C	37	47	⬭
D	47	37	⬭

2 9 A cylindrical rod **R** is made of a material with a density ρ.
R has mass m and diameter d.

Four other cylindrical rods **A**, **B**, **C** and **D** each have diameter $2d$.
The table shows the densities and masses of **A**, **B**, **C** and **D**.

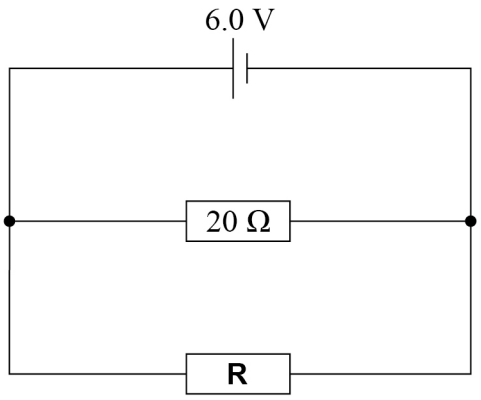
Which rod has the same length as **R**?

[1 mark]

Rod	Density	Mass	
A	2ρ	$2m$	⬭
B	2ρ	$4m$	⬭
C	2ρ	$8m$	⬭
D	4ρ	$4m$	⬭

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3 0 A cell of negligible internal resistance is connected in parallel to a $20\ \Omega$ resistor and a resistor **R**.



The emf of the cell is 6.0 V.
The current in the cell is 1.1 A.

What is the power dissipated in **R**?

[1 mark]

A 1.8 W ⬭

B 3.3 W ⬭

C 4.8 W ⬭

D 6.6 W ⬭

3 1 An aircraft flies horizontally with a constant velocity v.
The aircraft is subject to a constant resistive force F.
The aircraft engine has an efficiency of 10%.

How much energy must be transferred to the engine in one second?

[1 mark]

A $10Fv$ ⬭

B $11Fv$ ⬭

C $10Fv^2$ ⬭

D $11Fv^2$ ⬭

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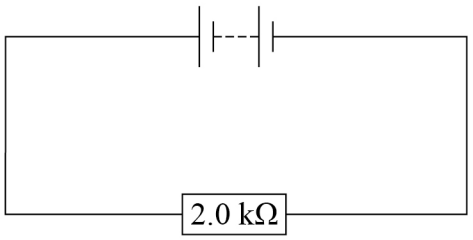
3 2 A nucleus of $^{15}_{8}\mathrm{O}$ emits a beta-plus particle.

Which row shows the number of protons and the number of neutrons in the resulting nucleus?

[1 mark]

	Number of protons	Number of neutrons	
A	9	7	⬭
B	9	6	⬭
C	7	8	⬭
D	7	7	⬭

3 3 A battery with negligible internal resistance is connected to a resistor of resistance $2.0\ \mathrm{k\Omega}$. The current in the battery is $6.0\ \mathrm{mA}$.



A non-ideal voltmeter is then connected in parallel with the resistor.
The current in the battery increases by $4.0\ \mathrm{mA}$.

What is the resistance of the voltmeter?

[1 mark]

A $2.0\ \mathrm{k\Omega}$ ⬭

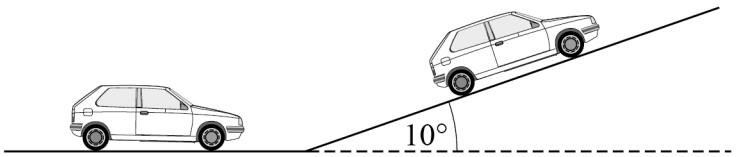
B $3.0\ \mathrm{k\Omega}$ ⬭

C $3.3\ \mathrm{k\Omega}$ ⬭

D $6.0\ \mathrm{k\Omega}$ ⬭

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3 4 A car moves along a horizontal road at a constant speed of $15\ \text{m s}^{-1}$.
The car's engine provides a constant thrust of $3800\ \text{N}$.
The car then travels up a hill. The slope of the hill is $10°$ to the horizontal.
The power of the car's engine increases so that the car continues at a constant speed of $15\ \text{m s}^{-1}$.



The weight of the car is $12\ 000\ \text{N}$.
Assume that resistive forces are constant.

What is the minimum power output of the engine as the car goes up the hill?

[1 mark]

A 31 kW ⬭

B 57 kW ⬭

C 88 kW ⬭

D 230 kW ⬭

30

END OF QUESTIONS

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