



Please write clearly in block capitals.

Centre number

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Candidate number

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Surname

*StemUp Model Solution*

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

### 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.

| For Examiner's Use |      |
|--------------------|------|
| Question           | Mark |
| 1                  |      |
| 2                  |      |
| 3                  |      |
| 4                  |      |
| 5–34               |      |
| <b>TOTAL</b>       |      |



J U N 2 5 7 4 0 7 2 0 1

## 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

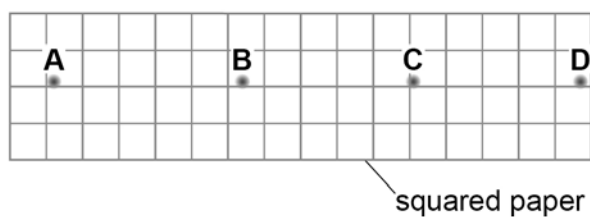
State **one** safety precaution when using a laser in a school laboratory.

[1 mark]

*Never look directly into the beam or at its reflections; stand behind the laser when it is switched on.*

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     | $x / \text{mm}$ |
|----------|-----------------|
| <b>A</b> | $60 \pm 5$      |
| <b>B</b> | $321 \pm 5$     |
| <b>C</b> | $553 \pm 5$     |
| <b>D</b> | $785 \pm 5$     |



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

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

**[2 marks]**

$$\Delta x = 553 - 60 = 493 \text{ mm}$$

$$\text{uncertainty in } \Delta x = 5 + 5 = 10 \text{ mm}$$

$$\% \text{ uncertainty} = (10 / 493) \times 100 = 2.0 \%$$

$$\Delta x = \underline{493} \text{ mm}$$

$$\text{percentage uncertainty} = \underline{2.0} \%$$

**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]**

$$d = 1 / 300 \text{ mm} = 3.33 \times 10^{-6} \text{ m}$$

$$\text{First order } (n = 1): x = 553 - 321 = 232 \text{ mm}$$

$$\tan \theta_1 = 0.232 / 1.20 = 0.193, \theta_1 = 10.9^\circ$$

$$\lambda = d \sin \theta_1 / 1 = 3.33 \times 10^{-6} \times 0.190 = 6.33 \times 10^{-7} \text{ m}$$

$$\text{Second order } (n = 2): x = 493 \text{ mm}$$

$$\tan \theta_2 = 0.493 / 1.20 = 0.411, \theta_2 = 22.3^\circ$$

$$\lambda = d \sin \theta_2 / 2 = 3.33 \times 10^{-6} \times 0.380 / 2 = 6.33 \times 10^{-7} \text{ m}$$

$$\text{Mean of the two values: } \lambda = 6.3 \times 10^{-7} \text{ m}$$

$$\text{wavelength} = \underline{6.3 \times 10^{-7}} \text{ m}$$

Question 1 continues on the next page

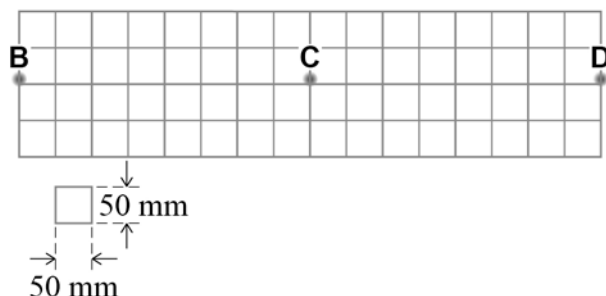
Turn over ►



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]

*B to C (first order) is now 8 squares =  $8 \times 50 = 400 \text{ mm}$*

*$\tan \theta_1 = 0.193$  (from 01.3, same grating and laser)*

*$\tan \theta_1 = 0.400 / L$*

*$L = 0.400 / 0.193$*

*$= 2.07 \text{ m} \approx 2.1 \text{ m}$*

distance = 2.1 m

8



**Turn over for the next question**

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0 5

0 2

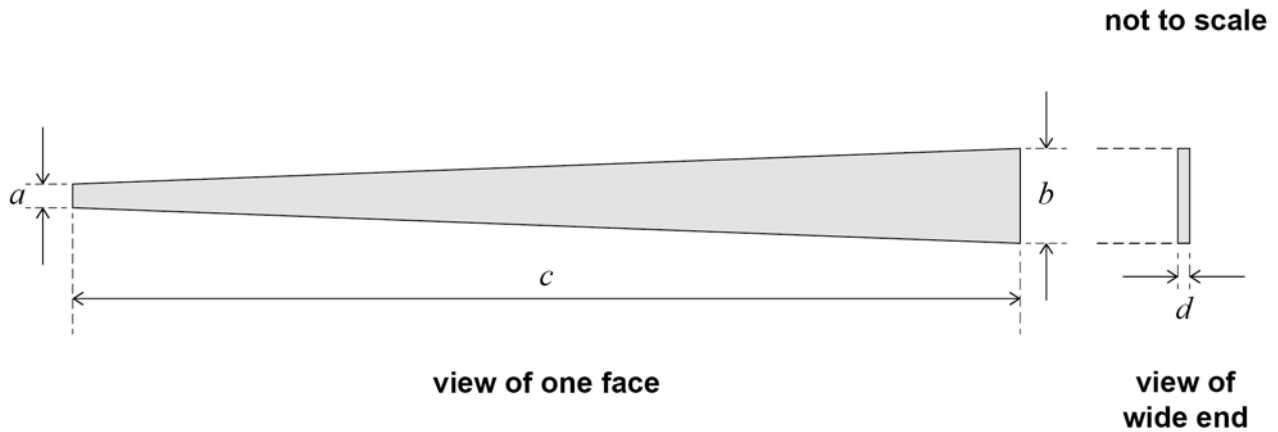
This question is about a method to determine the centre of mass of a tapered metal beam.

**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**



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**

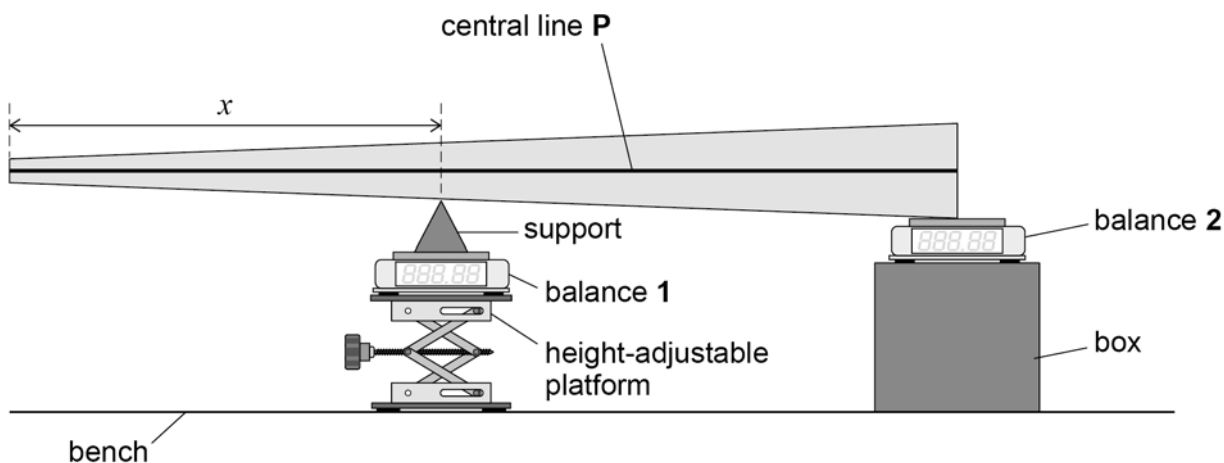
| Dimension | Value / mm | Instrument used         |
|-----------|------------|-------------------------|
| $a$       | 21.5       | vernier calipers        |
| $b$       | 86.0       | <i>vernier calipers</i> |
| $c$       | 900        | <i>metre ruler</i>      |
| $d$       | 9.74       | <i>micrometer</i>       |



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]

*Stand the metre ruler upright on the bench and place the set square against the bench and the ruler, so the metre ruler is vertical.*

*Use the vertical ruler to measure the vertical distance from the bench up to line P at two different points along the beam (e.g. near each end).*

*Line P is horizontal if these two distances are the same.*

Question 2 continues on the next page

Turn over ►



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.

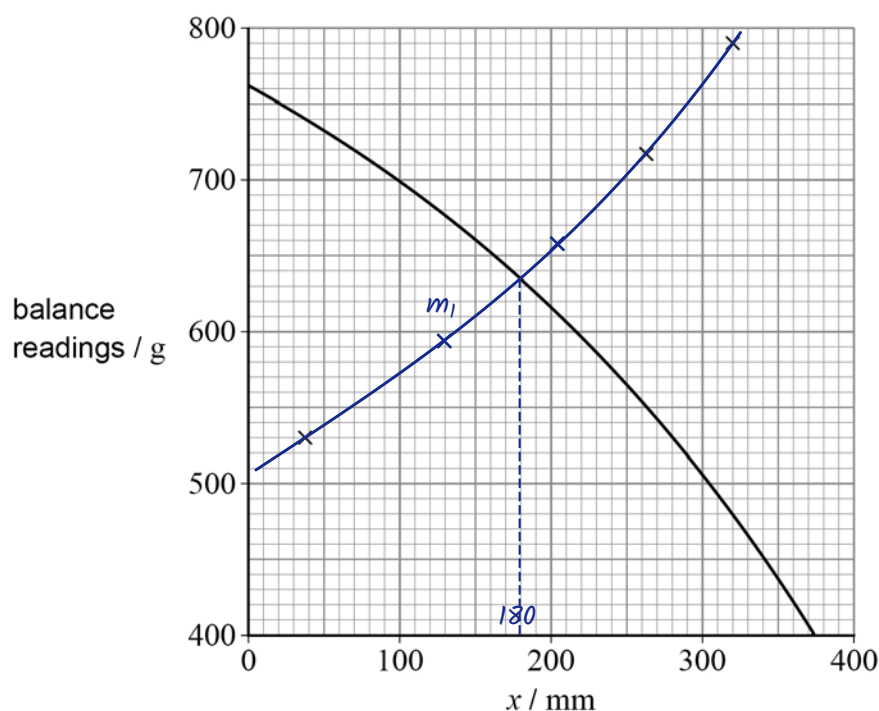
The platform, balance 1 and the support are then moved to change the value of  $x$ . The height of the platform is adjusted so that line P is horizontal.

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**

| $x / \text{mm}$ | $m_1 / \text{g}$ |
|-----------------|------------------|
| 130             | 594              |
| 205             | 658              |

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

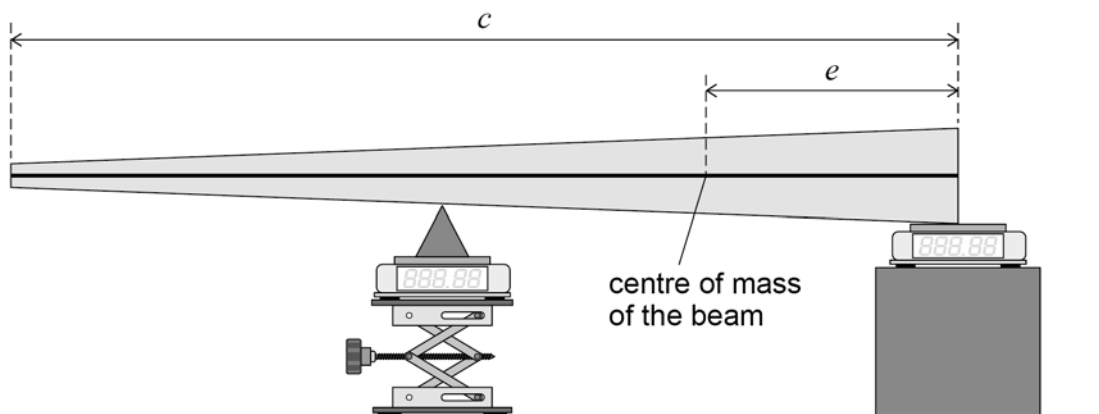
Determine an accurate value for the mass of the beam.

*At  $x = 130 \text{ mm}$ :  $m_1 = 594 \text{ g}$ ,  $m_2 = 677 \text{ g}$* 

[2 marks]

*mass =  $m_1 + m_2 = 594 + 677 = 1271 \text{ g}$* *At  $x = 205 \text{ mm}$ :  $658 + 612 = 1270 \text{ g}$ ; mean  $\approx 1270 \text{ g}$* mass of the beam = 1270 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**.

$$c = 900 \text{ mm}$$

*Lines cross ( $m_1 = m_2$ ) at  $x = 180 \text{ mm}$* 

[2 marks]

$$2e = c - x = 900 - 180 = 720 \text{ mm}$$

$$e = 720 / 2 = 360 \text{ mm}$$

 $e =$  360 mm

Question 2 continues on the next page

Turn over ►



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]

*All the values of  $m_1$  are larger, because balance 1 now also includes the mass of the support: same gradient but a greater y-intercept.*

- 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]

*The second student's  $m_1$  line is shifted upwards, so it intersects the  $m_2$  line at a smaller value of  $x$ .*

*Since  $2e = c - x$ , a smaller  $x$  gives a larger value of  $e$ , so the second student's  $e$  is larger than the correct value (the mass of the support appears to move the centre of mass towards the wide end).*

END OF SECTION A



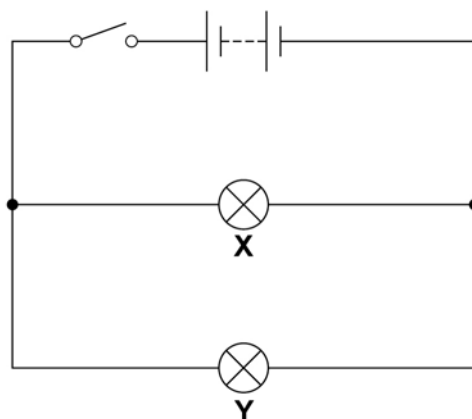
**Turn over for Section B**

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ANSWER IN THE SPACES PROVIDED**

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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 V and an internal resistance of 0.037  $\Omega$ .

When the switch is closed, each lamp operates at a power of 65 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]**

*Power supplied by the battery =  $\epsilon I = 12I$ . Power wasted in the internal resistance =  $I^2 r = 0.037I^2$ . Power used by the two lamps =  $2 \times 65 = 130$  W.*

*By conservation of energy, the power supplied by the battery equals the total power dissipated in the circuit, so  $12I = 0.037I^2 + 130$ .*



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

[2 marks]

$$0.037I^2 - 12I + 130 = 0 \quad (a = 0.037, b = -12, c = 130)$$

$$I = [12 - \sqrt{12^2 - 4 \times 0.037 \times 130}] / (2 \times 0.037)$$

$$= (12 - \sqrt{124.76}) / 0.074 = (12 - 11.170) / 0.074$$

$$= 11.2 \text{ A} \approx 11 \text{ A}$$

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

[2 marks]

$$\text{terminal pd } V = \varepsilon - Ir = 12 - (11.22 \times 0.037) = 11.58 \text{ V}$$

$$P = V^2 / R \text{ so } R = V^2 / P$$

$$R = 11.58^2 / 65$$

$$= 2.06 \, \Omega \approx 2.1 \, \Omega$$

resistance of **X** = 2.1  $\Omega$

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]

*The thinner filament has a smaller cross-sectional area, so the resistance of X increases ( $R = \rho L/A$ ).*

*The total (load) resistance of the parallel lamps increases, so the total current from the battery decreases.*

*The lost volts  $Ir$  decrease, so the terminal pd across the lamps increases (a larger share of the emf is across the load).*

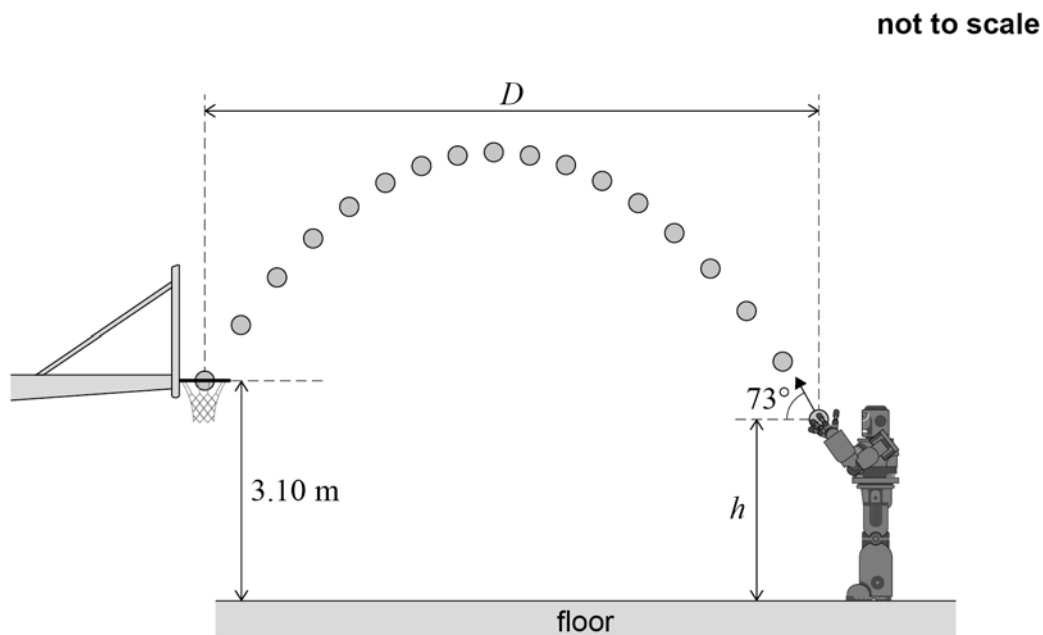
*Y has constant resistance and  $P = V^2/R$ , so the power of Y increases: Y no longer operates at 65 W, it is above 65 W.*

Turn over ►



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**

The robot throws the ball from a height  $h$  above the floor and at an angle of  $73^\circ$  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]**

$$\text{horizontal component } u_h = 8.7 / \tan 73^\circ = 2.66 \text{ m s}^{-1}$$

$$D = u_h \times t = 2.66 \times 1.7$$

$$= 4.52 \text{ m}$$

$$D = \underline{4.5} \text{ m}$$



0 4 . 2

The vertical displacement of the ball from the floor in the last image is 3.10 m.

Determine  $h$ .

*Taking upwards as positive:  $u = +8.7 \text{ m s}^{-1}$ ,  $a = -9.81 \text{ m s}^{-2}$ ,  $t = 1.7 \text{ s}$  [3 marks]*

$$s = ut + \frac{1}{2}at^2 = (8.7 \times 1.7) + \frac{1}{2} \times (-9.81) \times 1.7^2$$

$$= 14.79 - 14.18 = 0.61 \text{ m (ball ends 0.61 m above launch)}$$

$$s = 3.10 - h \text{ so } h = 3.10 - 0.61$$

$$= 2.49 \text{ m}$$

$$h = \underline{2.5} \text{ m}$$

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  $73^\circ$ .

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]

*With the same initial speed but a smaller angle, the horizontal component of the initial velocity is larger (and the vertical component smaller).*

*So the ball covers the same distance  $D$  in a shorter time of flight. The time interval is unchanged, so there are fewer images than in Figure 8.*

Question 4 continues on the next page

Turn over ►



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]

*Air resistance always acts in the opposite direction to the ball's velocity, and its magnitude increases as the speed increases.*

*Vertical displacement increasing (rising): air resistance has a downward component, in the same direction as the weight, so  $a_v$  is larger than  $g$  ( $9.81 \text{ m s}^{-2}$ ). As the ball rises it slows down, so the air resistance decreases and  $a_v$  decreases towards  $g$  at the top.*

*Vertical displacement decreasing (falling): air resistance has an upward component, opposite to the weight, so  $a_v$  is smaller than  $g$ . As the ball speeds up the air resistance increases, so  $a_v$  keeps decreasing as  $s_v$  decreases.*

10

END OF SECTION B



## 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



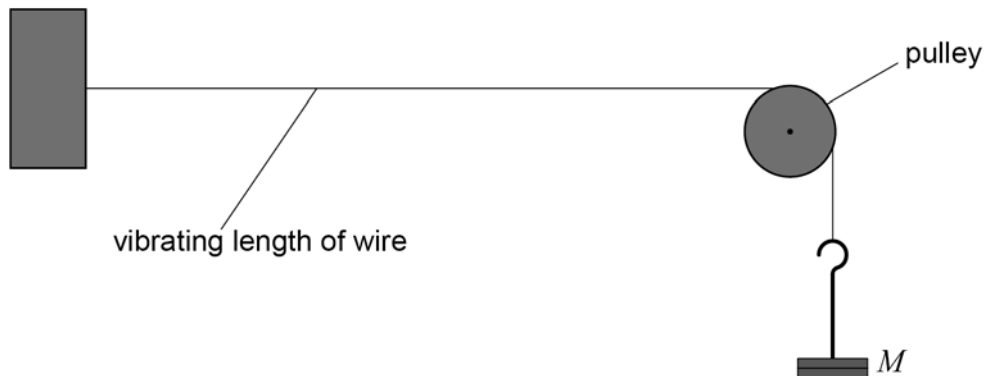
If you want to change your answer you must cross out your original answer as shown. 

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 ☐



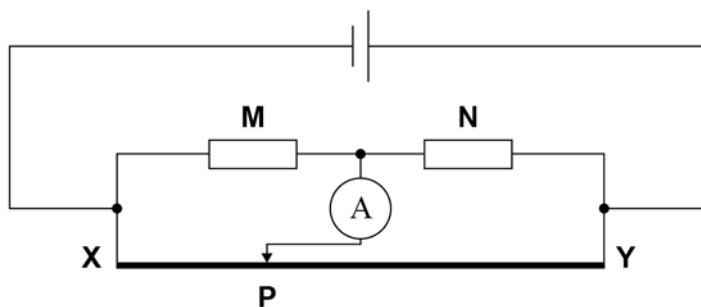
- 0 6** An electron and a proton have the same de Broglie wavelength.

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]

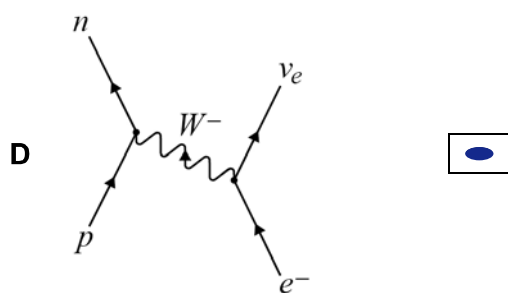
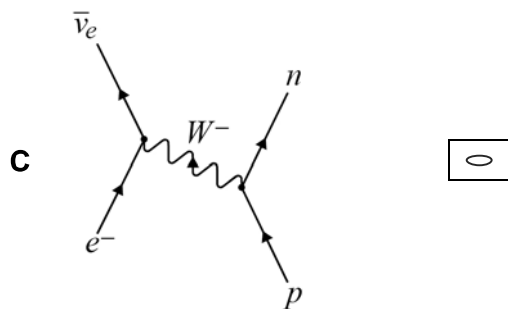
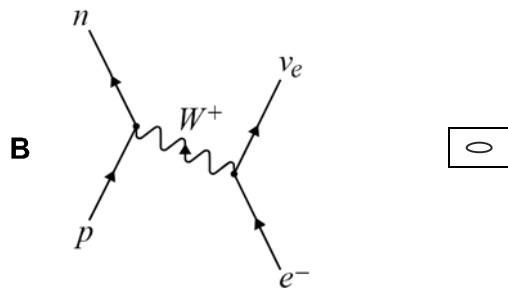
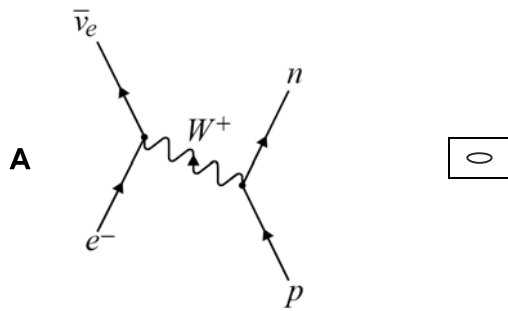
- A** **N** was replaced with a resistor of greater resistance. ☒
- B** **XY** was replaced with a wire of greater resistance. ☐
- C** The cell was replaced with one of greater emf. ☐
- D** The cell was replaced with one of greater internal resistance. ☐



0 8

Which diagram represents an electron–proton collision?

[1 mark]



Turn over for the next question

Turn over ►



**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 m s<sup>-1</sup> ☐

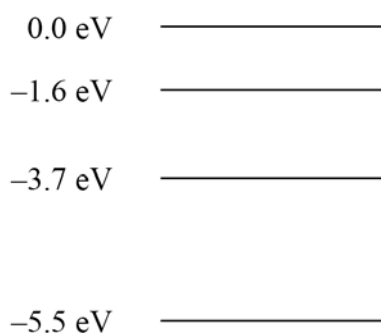
**B** 32 m s<sup>-1</sup> ☐

**C** 64 m s<sup>-1</sup> ☒

**D** 128 m s<sup>-1</sup> ☐

**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  $2.1 \times 10^{15}$  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**  $4.3 \times 10^{14}$  Hz ☐

**B**  $8.9 \times 10^{14}$  Hz ☐

**C**  $1.2 \times 10^{15}$  Hz ☐

**D**  $1.6 \times 10^{15}$  Hz ☒



1 1

Two coherent sources generate sound waves of wavelength 0.40 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 m.

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

[1 mark]

A zero

☒

B 45°

☐

C 90°

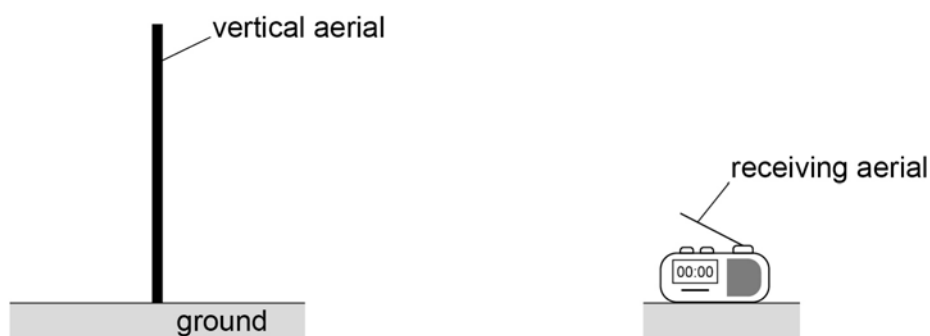
☐

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                      | <input checked="" type="radio"/> |
| B | polarised                        | horizontal                    | <input type="radio"/>            |
| C | unpolarised                      | vertical                      | <input type="radio"/>            |
| D | unpolarised                      | horizontal                    | <input type="radio"/>            |



**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                      |                                  |
|----------|---------------------------------------|-----------------------------------------------------|----------------------------------|
| <b>A</b> | time for <b>X</b> < time for <b>Y</b> | upward force on <b>X</b> > upward force on <b>Y</b> | <input type="radio"/>            |
| <b>B</b> | time for <b>X</b> = time for <b>Y</b> | upward force on <b>X</b> = upward force on <b>Y</b> | <input type="radio"/>            |
| <b>C</b> | time for <b>X</b> > time for <b>Y</b> | upward force on <b>X</b> = upward force on <b>Y</b> | <input type="radio"/>            |
| <b>D</b> | time for <b>X</b> > time for <b>Y</b> | upward force on <b>X</b> > upward force on <b>Y</b> | <input checked="" type="radio"/> |

**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 ☐



- 1 5** A cylindrical beaker contains water. The diameter of the water surface is 200 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 |                                  |
|----------|---------------------|---------------------|----------------------------------|
| <b>A</b> | 50                  | towards centre      | <input checked="" type="radio"/> |
| <b>B</b> | 50                  | away from centre    | <input type="radio"/>            |
| <b>C</b> | 150                 | towards centre      | <input type="radio"/>            |
| <b>D</b> | 150                 | away from centre    | <input type="radio"/>            |

- 1 6** A string vibrates at the  $N$ th harmonic.  
The separation  $x$  between adjacent nodes is 0.60 m.

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

What is  $N$ ?

[1 mark]

- A** 3 ☐
- B** 4 ☒
- C** 5 ☐
- D** 6 ☐

Turn over ►



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

[1 mark]

**A**  $\text{J m}^{-1}$  ☐

**B**  $\text{kg m s}^{-2}$  ☐

**C**  $\text{W s}^{-2}$  ☒

**D**  $\text{W s m}^{-1}$  ☐

**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.

|                | <b>A</b>       | <b>B</b>       | <b>C</b>       | <b>D</b>       |
|----------------|----------------|----------------|----------------|----------------|
| $V / \text{V}$ | $I / \text{A}$ | $I / \text{A}$ | $I / \text{A}$ | $I / \text{A}$ |
| 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** ☐

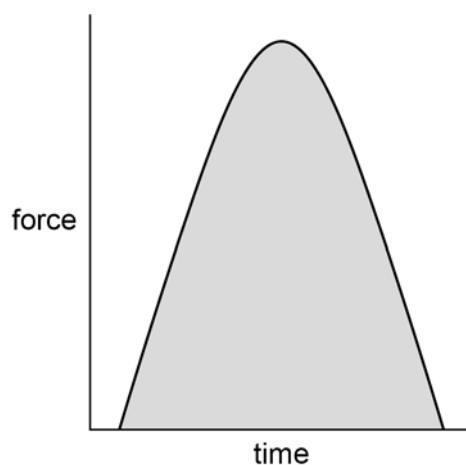
**C** ☒

**D** ☐



**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**  $v \propto \frac{1}{x^2}$

☐


**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.



$$X_P = \frac{\text{stress in P}}{\text{strain of P}}$$

$$X_Q = \frac{\text{stress in Q}}{\text{strain of Q}}$$

$X_Q$  is equal to:

[1 mark]

**A**  $\frac{X_P}{4}$  ☐

**B**  $X_P$  ☒

**C**  $2X_P$  ☐

**D**  $4X_P$  ☐

**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. ☐

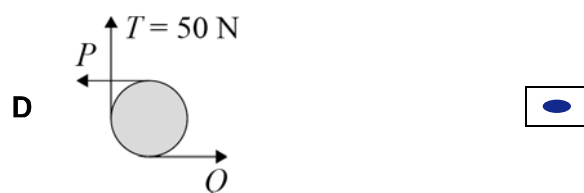
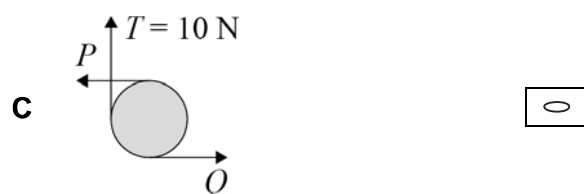
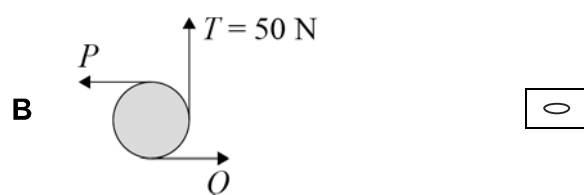
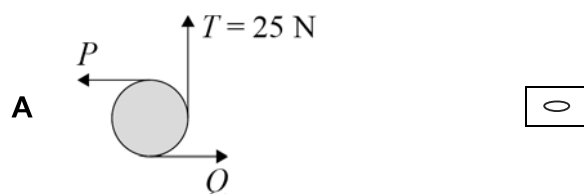
**D** They form stationary waves. ☐



**2 3**

A uniform disc of weight 50 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 N.  $P$ ,  $Q$  and  $T$  are tangential to the rim of the disc.

Which diagram shows the system in equilibrium?

**[1 mark]**

Turn over for the next question

Turn over ►



**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**  $\frac{Ax}{2EL}$  ☐

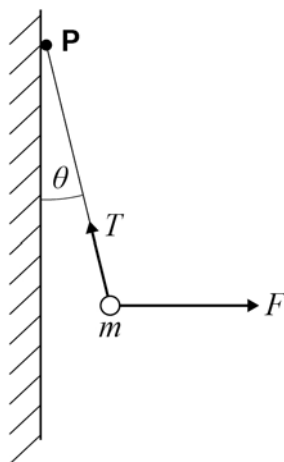
**B**  $\frac{AEx}{2L}$  ☐

**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  $\theta$  to the vertical position.  
The system is in equilibrium.



What is correct for this system?

**[1 mark]**

**A**  $F = T\cos\theta$  ☐

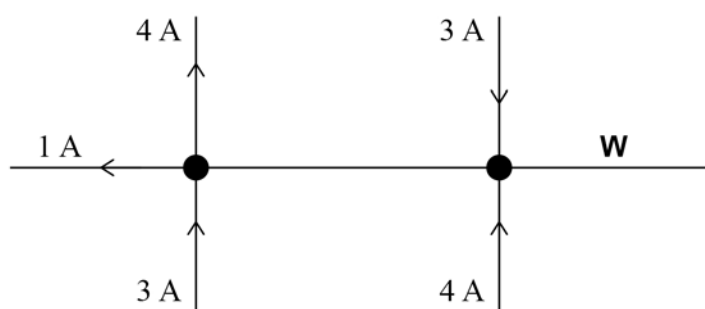
**B**  $(mg)^2 = T^2 + F^2$  ☐

**C**  $mg = T\sin\theta$  ☐

**D**  $mg\sin\theta = F\cos\theta$  ☒



- 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 ►



**2 8** What is the number of down quarks and the number of up quarks in a nucleus of  ${}^{19}_9\text{F}$ ?

[1 mark]

|          | Number of down quarks | Number of up quarks |                                  |
|----------|-----------------------|---------------------|----------------------------------|
| <b>A</b> | 28                    | 29                  | <input type="radio"/>            |
| <b>B</b> | 29                    | 28                  | <input checked="" type="radio"/> |
| <b>C</b> | 37                    | 47                  | <input type="radio"/>            |
| <b>D</b> | 47                    | 37                  | <input type="radio"/>            |

**2 9** A cylindrical rod **R** is made of a material with a density  $\rho$ .  
**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**?

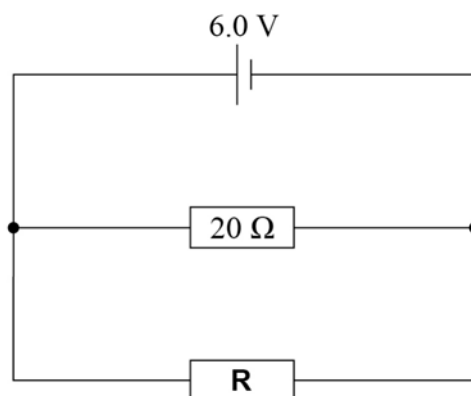
[1 mark]

| Rod      | Density | Mass |                                  |
|----------|---------|------|----------------------------------|
| <b>A</b> | $2\rho$ | $2m$ | <input type="radio"/>            |
| <b>B</b> | $2\rho$ | $4m$ | <input type="radio"/>            |
| <b>C</b> | $2\rho$ | $8m$ | <input checked="" type="radio"/> |
| <b>D</b> | $4\rho$ | $4m$ | <input type="radio"/>            |



**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**  $11Fv^2$  ☐



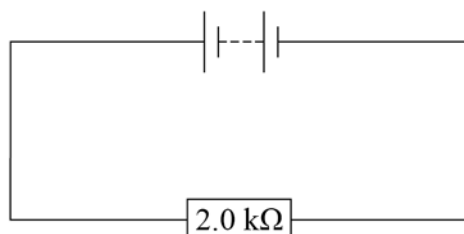
**3 2** A nucleus of  $^{15}_8\text{O}$  emits a beta-plus particle.

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

[1 mark]

|          | Number of protons | Number of neutrons |                                  |
|----------|-------------------|--------------------|----------------------------------|
| <b>A</b> | 9                 | 7                  | <input type="radio"/>            |
| <b>B</b> | 9                 | 6                  | <input type="radio"/>            |
| <b>C</b> | 7                 | 8                  | <input checked="" type="radio"/> |
| <b>D</b> | 7                 | 7                  | <input type="radio"/>            |

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



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

What is the resistance of the voltmeter?

[1 mark]

- A**  $2.0\text{ k}\Omega$  ☐
- B**  $3.0\text{ k}\Omega$  ☒
- C**  $3.3\text{ k}\Omega$  ☐
- D**  $6.0\text{ k}\Omega$  ☐



**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  $10^\circ$  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**  $31 \text{ kW}$  ☐
- B**  $57 \text{ kW}$  ☐
- C**  $88 \text{ kW}$  ☒
- D**  $230 \text{ kW}$  ☐

**30****END OF QUESTIONS**

**There are no questions printed on this page**

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ANSWER IN THE SPACES PROVIDED**



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