



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.

A-level PHYSICS

Paper 1

Friday 23 May 2025

Morning

Time allowed: 2 hours

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 85.
- 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	
6	
7	
8	
9–33	
TOTAL	



J U N 2 5 7 4 0 8 1 0 1

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Section A

Answer **all** questions in this section.

0 1

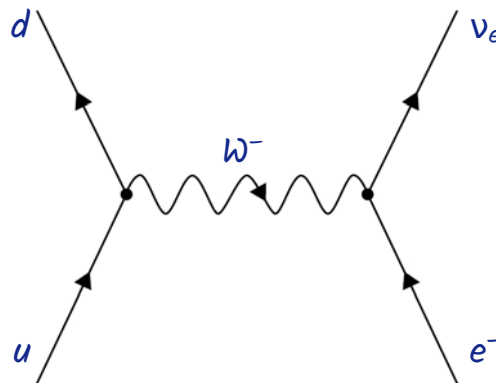
This question is about an isotope of titanium that **only** decays by electron capture.

0 1 . 1

Complete **Figure 1** to show the quark change that occurs during electron capture. Label the incoming and outgoing particles and the exchange particle.

[3 marks]

Figure 1



0 1 . 2

In some circumstances, a nucleus of this isotope can exist with **no** orbiting electrons.

Explain why a neutral atom of this isotope is **less stable** than a nucleus that has no orbiting electrons.

[1 mark]

It only decays by electron capture, so the nucleus needs an (inner shell) orbiting electron to capture in order to decay. A nucleus with no orbiting electrons has no electron to capture, so it cannot decay, while the neutral atom can.



0 1 . 3

A nucleus of this isotope of titanium has a proton number of 22 and a specific charge of $4.8 \times 10^7 \text{ C kg}^{-1}$.

Determine the number of neutrons in this nucleus.

[2 marks]

$$\text{charge of nucleus } Q = 22 \times 1.60 \times 10^{-19} = 3.52 \times 10^{-18} \text{ C}$$

$$\text{mass} = Q / \text{specific charge} = 3.52 \times 10^{-18} / 4.8 \times 10^7$$

$$\text{mass} = 7.33 \times 10^{-26} \text{ kg}$$

$$\text{number of nucleons} = 7.33 \times 10^{-26} / 1.67 \times 10^{-27} = 43.9 \approx 44$$

$$\text{number of neutrons} = 44 - 22 = 22$$

number of neutrons = 22

6

Turn over for the next question

Turn over ►



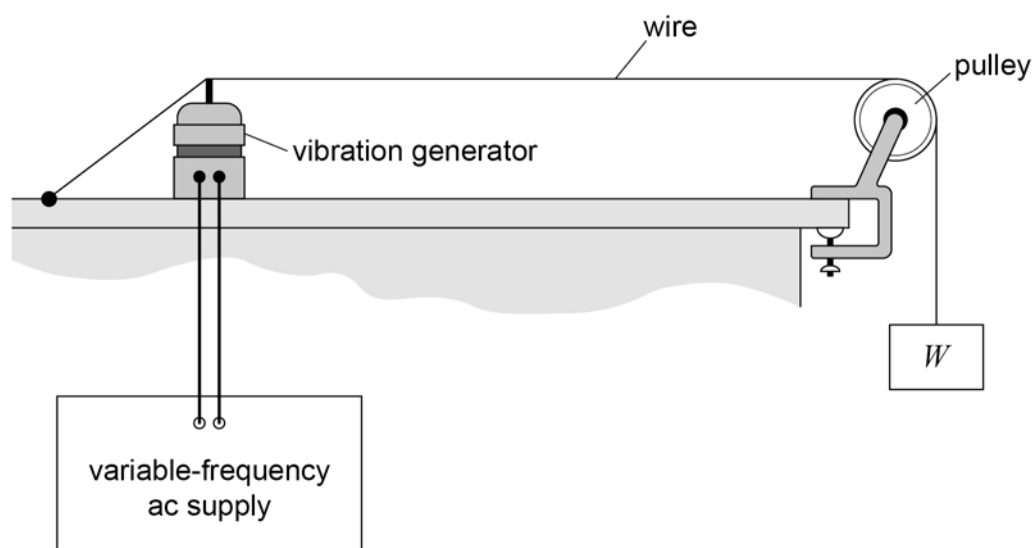
0 2 . 1

State what is meant by a transverse wave.

[2 marks]

*A wave in which the oscillations of the particles are at right angles
(perpendicular) to the direction of energy transfer of the wave.*

Figure 2 shows apparatus that is used to investigate stationary waves on a stretched wire.

Figure 2

A block of weight W is used to keep the wire under tension.

The frequency of the ac supply is varied until a stationary wave is produced on the wire.

0 2 . 2

Explain how a stationary wave is produced on the wire.

[1 mark]

*The wave from the vibration generator is reflected at the pulley, so two
waves travel in opposite directions along the wire and superpose.*

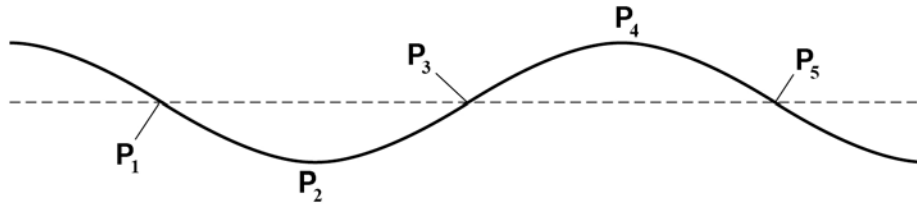


0 2 . 3

Figure 3 shows a small section of the wire at one instant.
Five points on the wire are labelled P_1 to P_5 .

The dashed line represents the position of the wire when the ac supply is turned off.

Figure 3



Describe how the phase of the oscillating particles varies along the wire between P_1 and P_5 .

[2 marks]

*All the particles between P_1 and P_3 oscillate in phase with each other,
and all the particles between P_3 and P_5 oscillate in phase with each
other.*

*The particles between P_1 and P_3 are in antiphase (180° out of phase)
with those between P_3 and P_5 , e.g. P_2 and P_4 are in antiphase.*

Question 2 continues on the next page

Turn over ►



0 2 . 4

A student investigates stationary waves on a wire using the apparatus in **Figure 2**. The investigation requires the student to produce the first five harmonics on the wire.

The student needs to choose **one** of two wires, **A** or **B**, for the investigation.

The mass of a 2.00 m length of wire **A** is 1.32 g.

The mass of a 2.00 m length of wire **B** is 2.94 g.

The ac supply can produce signals in the range 1 Hz to 50 Hz.

The length of the wire that vibrates between the vibration generator and the pulley is 1.50 m.

The student needs to choose **one** value for weight W for the investigation.

W can be either 1.0 N or 5.0 N.

Determine, in kg m^{-1} , the mass per unit length of each wire.

Go on to suggest which wire and which value of W the student should use to produce the first five harmonics.

[5 marks]

$$\mu = \text{mass} / \text{length}: \mu_A = 1.32 \times 10^{-3} / 2.00 = 6.60 \times 10^{-4} \text{ kg m}^{-1}$$

$$\mu_B = 2.94 \times 10^{-3} / 2.00 = 1.47 \times 10^{-3} \text{ kg m}^{-1}$$

$$\text{mass per unit length of A} = \underline{6.60 \times 10^{-4}} \text{ kg m}^{-1}$$

$$\text{mass per unit length of B} = \underline{1.47 \times 10^{-3}} \text{ kg m}^{-1}$$

$$\text{First harmonic: } f_1 = (1 / 2L) \sqrt{(T / \mu)}, \text{ where } 2L = 2 \times 1.50 = 3.00 \text{ m}$$

$$\text{For five harmonics } f_5 = 5f_1 \leq 50 \text{ Hz, so need } f_1 \leq 10 \text{ Hz}$$

$$\text{A, } W = 1.0 \text{ N: } f_1 = 13.0 \text{ Hz, } f_5 = 65.0 \text{ Hz} > 50 \text{ Hz (too high)}$$

$$\text{A, } W = 5.0 \text{ N: } f_1 = 29.0 \text{ Hz, } f_5 = 145 \text{ Hz} > 50 \text{ Hz (too high)}$$

$$\text{B, } W = 1.0 \text{ N: } f_1 = 8.7 \text{ Hz, } f_5 = 43.5 \text{ Hz} \leq 50 \text{ Hz}$$

$$\text{B, } W = 5.0 \text{ N: } f_1 = 19.4 \text{ Hz, } f_5 = 97.0 \text{ Hz} > 50 \text{ Hz (too high)}$$

$$\text{Only wire B with } W = 1.0 \text{ N gives a fifth harmonic below 50 Hz}$$

$$\text{(the greatest that does not exceed 50 Hz), so all five are possible.}$$

$$\text{wire} = \underline{\text{B}} \quad W = \underline{1.0} \text{ N}$$

10



0 3

A mass-spring system is undergoing simple harmonic motion (SHM).
The maximum velocity of the mass is 0.39 m s^{-1} and the period of oscillation is 0.81 s .

0 3 . 1

Draw, on **Figure 4**, a graph of acceleration against displacement for the system.
Label each axis with a suitable unit and scale.

[4 marks]

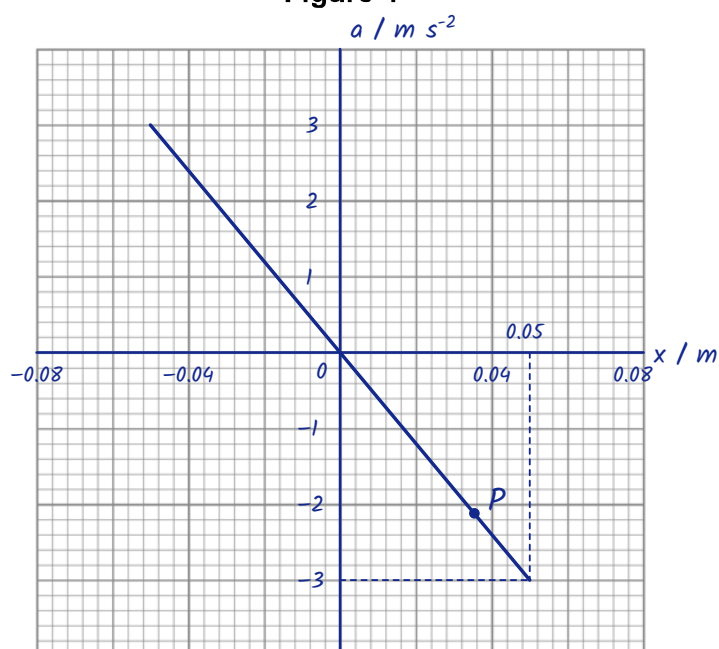
$$\omega = 2\pi / T = 2\pi / 0.81 = 7.76 \text{ rad s}^{-1}$$

$$A = v_{\max} / \omega = 0.39 / 7.76 = 0.050 \text{ m}$$

$$a = -\omega^2 x$$

$$a_{\max} = \omega^2 A = 7.76^2 \times 0.050 = 3.0 \text{ m s}^{-2}$$

Figure 4



0 3 . 2

Label, with a **P**, a point on your graph where the mass has 50% of its maximum kinetic energy.

[1 mark]

$$P: x = A / \sqrt{2} = 0.035 \text{ m}, a = -2.1 \text{ m s}^{-2}$$

$$(\frac{1}{2}kx^2 = \frac{1}{2} \text{ of max energy, so } E_k = 50\% \text{ of maximum})$$

5

Turn over ►



- 0 4 . 1** Explain why the Young modulus and the breaking stress of a wire have the same SI unit.

[1 mark]

*Young modulus = tensile stress / tensile strain, and strain has no unit,
so the Young modulus has the same unit as stress (Pa).*

Table 1 contains data about four metal wires **W**, **X**, **Y** and **Z**.

Table 1

Wire	Length / m	Diameter / mm	Stiffness / N m ⁻¹	Density / kg m ⁻³
W	3.10	1.7	4.90×10^4	2.71×10^3
X	2.17	1.4	5.25×10^4	1.93×10^4
Y	2.50	1.2	5.25×10^4	8.91×10^3
Z	2.50	1.2	3.08×10^4	2.71×10^3

- 0 4 . 2** The metal used to make wire **X** costs £75 per gram.

Calculate, in £, the cost of wire **X**.

[3 marks]

$$V = \pi r^2 L = \pi \times (0.70 \times 10^{-3})^2 \times 2.17 = 3.34 \times 10^{-6} \text{ m}^3$$

$$m = \rho V = 1.93 \times 10^4 \times 3.34 \times 10^{-6} = 0.0645 \text{ kg} = 64.5 \text{ g}$$

$$\text{cost} = 75 \times 64.5 = \text{£}4840$$

$$\text{cost} = \text{£} \underline{4840}$$

- 0 4 . 3** State and explain which of the wires in **Table 1** are made from the same material.

[1 mark]

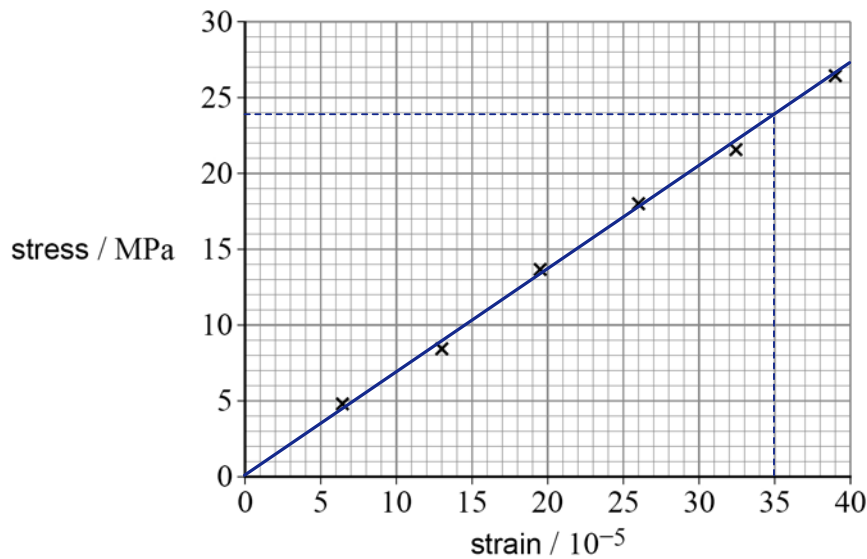
*W and Z, because they have the same density (density is the only
property of the material, not of the wire's size).*



0 4 . 4

One of the wires in **Table 1** was used to obtain the stress–strain data shown in **Figure 5**.

Figure 5



Draw a line of best fit on **Figure 5**.

Go on to deduce, using your line of best fit and **Table 1**, whether wire **W** could have been used to produce **Figure 5**.

[4 marks]

From the line: at strain 35×10^{-5} , stress = 23.8 MPa

$$E = \text{stress} / \text{strain} = 23.8 \times 10^6 / 35 \times 10^{-5} = 6.8 \times 10^{10} \text{ Pa}$$

$$\text{For W: } A = \pi d^2 / 4 = \pi \times (1.7 \times 10^{-3})^2 / 4 = 2.27 \times 10^{-6} \text{ m}^2$$

$$k = EA / L, \text{ so } E = kL / A = 4.90 \times 10^4 \times 3.10 / 2.27 \times 10^{-6}$$

$$E \text{ for W} = 6.7 \times 10^{10} \text{ Pa}$$

E for W ($6.7 \times 10^{10} \text{ Pa}$) is the same as E from Figure 5 ($6.8 \times 10^{10} \text{ Pa}$) within experimental error, so yes, wire W could have been used.



0 5

This question is about the batteries used to store energy in electric vehicles. Each battery is a series of modules. Each module is an array of identical cells.

Table 2 shows the properties of one of these cells.

Table 2

emf	3.66 V
internal resistance	30.0 mΩ
maximum current	6.77 A

0 5

1

Calculate the terminal potential difference of the cell at its maximum current.

[1 mark]

$$V = \varepsilon - Ir = 3.66 - (6.77 \times 0.0300)$$

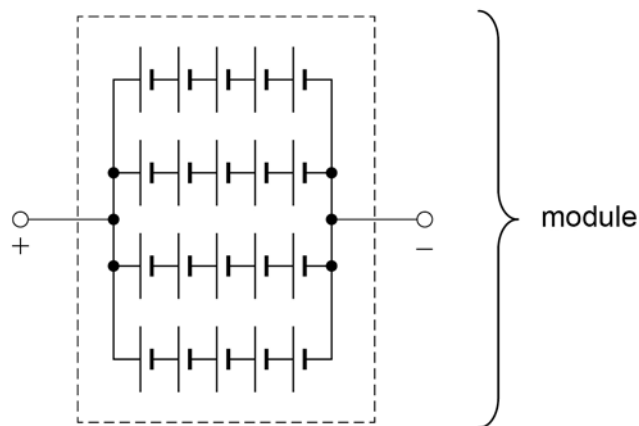
terminal potential difference = 3.46 V

0 5

2

Figure 6 shows an array of 20 of these cells connected to form a module.

Figure 6



Calculate the internal resistance of the module shown in **Figure 6**.

[2 marks]

$$\text{One row: 5 cells in series, } r = 5 \times 0.0300 = 0.150 \, \Omega$$

$$4 \text{ identical rows in parallel: } r = 0.150 / 4$$

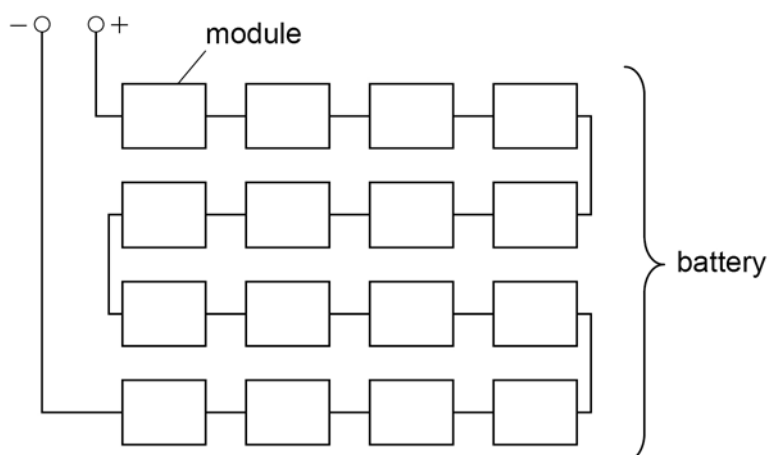
internal resistance = 0.0375 Ω



0 5 . 3

Figure 7 shows the battery for an electric vehicle.
This battery has an emf of 352 V and gives a maximum current of 500 A.

The battery consists of a series of identical modules.
These modules are **different** from the module shown in **Figure 6**.

Figure 7

The individual cells used in each module have the properties shown in **Table 2**.

Deduce the number of cells in each module.

[3 marks]

16 modules in series, so emf of each module = $352 / 16 = 22.0 \text{ V}$

cells in series in each row = $22.0 / 3.66 = 6.01$, so 6 cells per row

rows in parallel = maximum current / cell current

= $500 / 6.77 = 73.9$, so 74 rows

number of cells = $6 \times 74 = 444$

number of cells = 444

6

Turn over ►

0 6

A person kicks a stationary football horizontally.

During the kick, the person gives an impulse of 6.55 N s to the ball during a contact time of 12.0 ms.

The mass of the football is 410 g.

Assume that friction forces are negligible.

0 6

. 1

Calculate the kinetic energy transferred to the ball during the kick.

[2 marks]

$$\text{impulse} = m\Delta v, u = 0: v = 6.55 / 0.410 = 15.98 \text{ m s}^{-1}$$

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.410 \times 15.98^2 = 52.3 \text{ J}$$

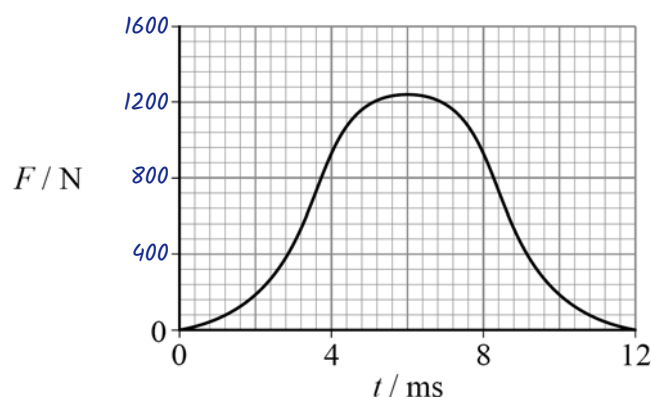
kinetic energy = 52.3 J

0 6

. 2

Figure 8 shows how the force F acting on the ball varies with time t .

Figure 8



Determine the scale for the F / N axis and add your scale to Figure 8.

[3 marks]

$$\text{area under graph} \approx 8.5 \text{ large squares, and area} = \text{impulse} = 6.55 \text{ N s}$$

$$\text{area of one large square} = 6.55 / 8.5 = 0.771 \text{ N s}$$

$$\text{width of a square} = 2 \text{ ms, so height} = 0.771 / 2 \times 10^{-3} = 385 \text{ N}$$

$$\text{so each large square on the } F \text{ axis} \approx 400 \text{ N}$$

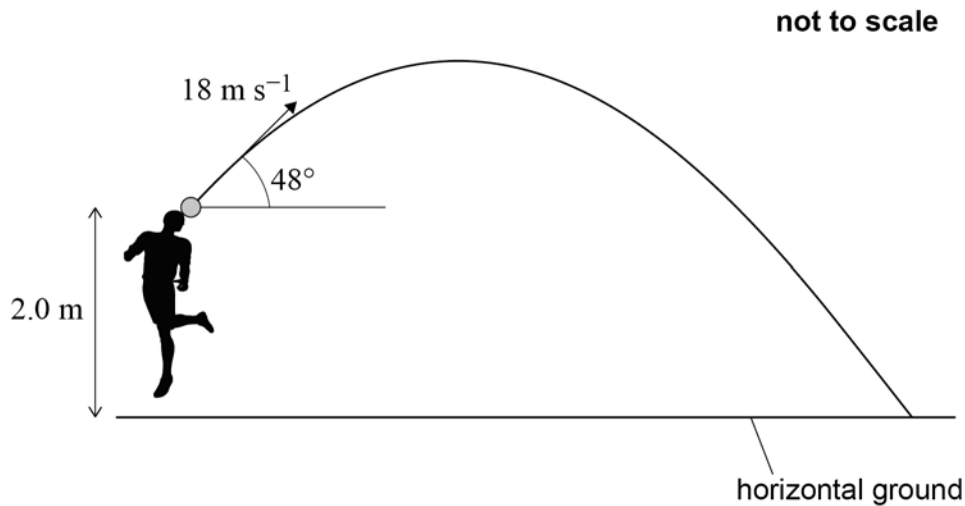


0 6 . 3

A player jumps up to head a football when it is 2.0 m above the ground. The initial velocity of the ball is 18 m s^{-1} at an angle of 48° to the horizontal.

Figure 9 shows the path of the ball above horizontal ground.

Figure 9



Determine the time that the ball takes to reach the ground from the instant it leaves the player's head.

Assume that the frictional forces acting on the ball are negligible.

[3 marks]

$$u_y = 18 \sin 48^\circ = 13.38 \text{ m s}^{-1} \text{ (taking upwards as positive)}$$

$$s = ut + \frac{1}{2}at^2: -2.0 = 13.38t - \frac{1}{2} \times 9.81 \times t^2$$

$$4.905t^2 - 13.38t - 2.0 = 0$$

$$t = [13.38 + \sqrt{(13.38^2 + 4 \times 4.905 \times 2.0)}] / (2 \times 4.905)$$

$$t = 2.87 \text{ s}$$

time = 2.87 s

8

Turn over for the next question

Turn over ►



0 7

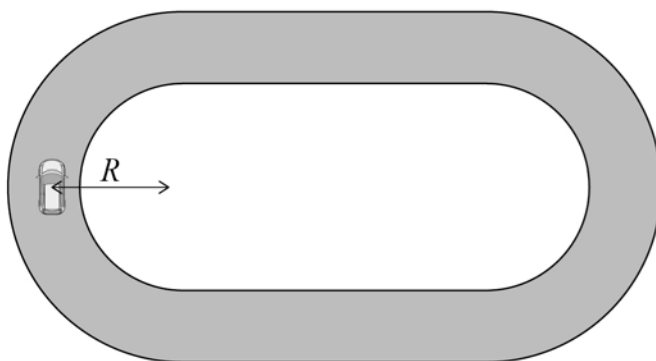
A racing car of mass m travels around a horizontal oval track. The curved sections of the track are semicircles.

0 7 . 1

At the instant shown in **Figure 10** the car is moving with constant speed v in a circle of radius R .

Figure 10

not to scale



The car has kinetic energy E_k .

The resultant force acting on the car is F .

Show that $R = \frac{2E_k}{F}$

[2 marks]

$$E_k = \frac{1}{2}mv^2, \text{ so } mv^2 = 2E_k$$

$$\text{centripetal force } F = mv^2 / R$$

$$\text{so } F = 2E_k / R, \text{ giving } R = 2E_k / F$$

The maximum centripetal force that can be produced between the car's tyres and the track is 24 kN.

The minimum value of R is 230 m.

$$m = 1600 \text{ kg}$$

0 7 . 2

The car just starts to slip when it travels on the track in a circular path of radius 230 m.

Deduce the speed of the car.

[1 mark]

$$F = mv^2 / R: v = \sqrt{FR / m} = \sqrt{(24 \times 10^3 \times 230 / 1600)}$$

$$\text{speed} = \underline{58.7} \text{ m s}^{-1}$$



07.3

The driver wishes to drive this car around the curved section of the track, without slipping, at a speed greater than your answer to Question 07.2.

Suggest **one** way in which the driver can achieve this.

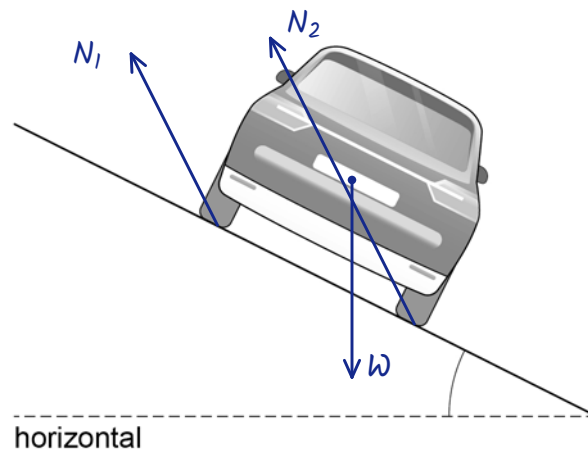
[1 mark]

*Drive along a path of larger radius, e.g. start at the outside of the track
and move to the inside of the curve.*

Figure 11 shows the car on the curved section of a different oval track. The curved section of this track is a slope. This means that cars can travel at greater speeds than on the track shown in **Figure 10**.

Figure 11

not to scale



07.4

The car in **Figure 11** stays at the same height on the curved section of the track. There is no tendency for the car to slip up or down the track and therefore there is no sideways friction on the tyres.

Draw and label, on **Figure 11**, arrows to show the direction of each force that acts on the car as it travels around the curved section of the track.

[2 marks]

Question 7 continues on the next page

Turn over ►



0 7 . 5

A car has a greater maximum speed on a sloped track than on a horizontal track of the same radius.

Explain why.

[2 marks]

On the slope the normal reaction force from the track is at an angle to the vertical, so it has a horizontal component towards the centre of the circle. This increases the (maximum) centripetal force on the car.

Since $F = mv^2 / R$, a greater centripetal force for the same radius means that v can be greater.

8



0 8

Electrons in a fluorescent tube are accelerated from rest by a potential difference of 130 V.

0 8 . 1

Calculate the maximum speed of an electron that is accelerated from rest by this potential difference.

[2 marks]

$$eV = \frac{1}{2}mv^2, \text{ so } v = \sqrt{(2eV / m)}$$

$$v = \sqrt{(2 \times 1.60 \times 10^{-19} \times 130 / 9.11 \times 10^{-31})}$$

maximum speed = 6.8×10^6 m s⁻¹

0 8 . 2

Explain why the average speed of the electrons in the tube is much less than the maximum speed you calculated in Question **08.1**.

[1 mark]

The electrons collide (inelastically) with the mercury atoms in the tube and transfer kinetic energy to them, so the average kinetic energy, and so the average speed, of the electrons is much lower.

Question 8 continues on the next page

Turn over ►

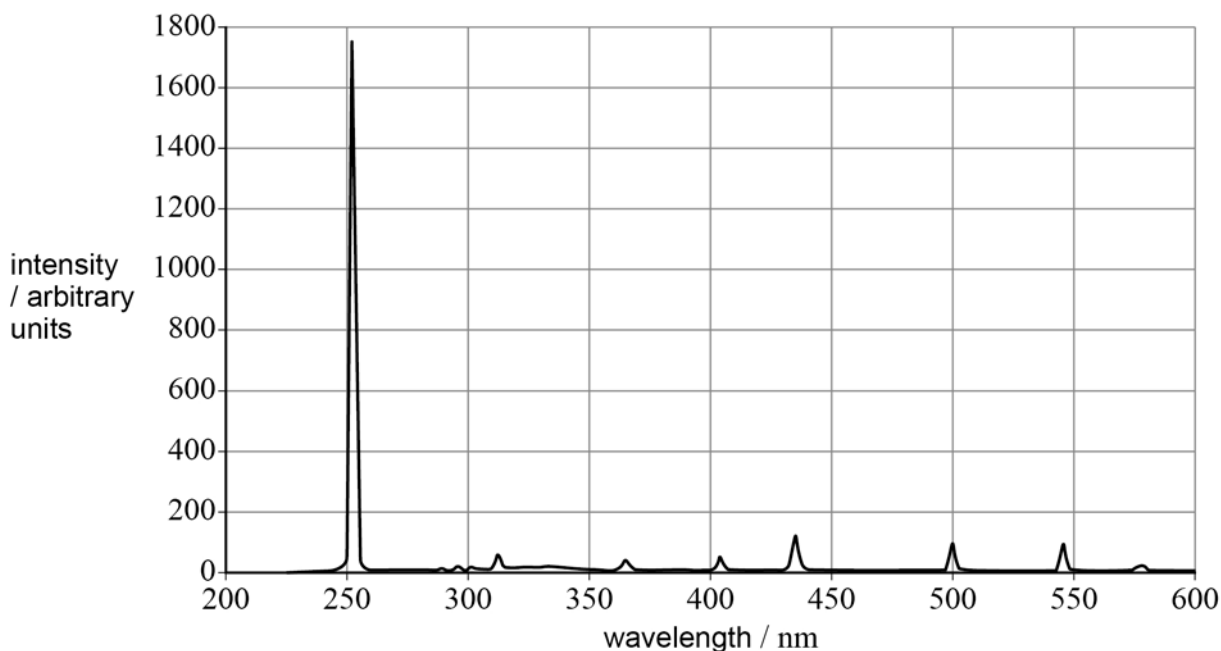


0 8 . 3

Scientists want to replace the mercury in fluorescent tubes with substance **X**.

Figure 12 is an emission spectrum for **X**.

Figure 12



White light consists of the whole range of visible wavelengths from 380 nm to 700 nm.

Explain, with reference to **Figure 12**, whether white light can be produced by a fluorescent tube that uses **X**.

[2 marks]

Yes. Figure 12 shows that most of the photons released by X are in the ultraviolet part of the spectrum; the peak at about 253 nm is far more intense than the few visible lines.

This UV radiation is absorbed by the phosphor coating on the tube, exciting its atoms; when they de-excite they emit longer wavelength (visible) radiation across the whole visible range, so white light can be produced.

0 8 . 4

Figure 12 shows a maximum intensity peak that occurs at wavelength λ_{peak} .

Calculate, in eV, the energy change of an atom that produces a photon with a wavelength λ_{peak} .

[3 marks]

$$\text{From Figure 12, } \lambda_{\text{peak}} = 253 \text{ nm} = 2.53 \times 10^{-7} \text{ m}$$

$$E = hc / \lambda = 6.63 \times 10^{-34} \times 3.00 \times 10^8 / 2.53 \times 10^{-7}$$

$$E = 7.86 \times 10^{-19} \text{ J}$$

$$\text{in eV: } E = 7.86 \times 10^{-19} / 1.60 \times 10^{-19} = 4.9 \text{ eV}$$

energy change = 4.9 eV

8

END OF SECTION A

Turn over ►



Section B

Each of Questions 09 to 33 is followed by four responses, A, B, C and D.

For each question select the best response.

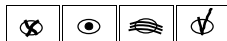
Only **one** answer per question is allowed.

For each question, completely fill in the circle alongside the appropriate answer.

CORRECT METHOD



WRONG METHODS



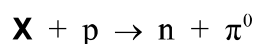
If you want to change your answer you must cross out your original answer as shown. 

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 9

The following equation represents a strong interaction between particle **X** and a proton.



What is the quark configuration of **X**?

[1 mark]

A $\bar{u}\bar{u}\bar{d}$ ☐

B $s\bar{u}$ ☐

C $d\bar{u}$ ☒

D $u\bar{d}$ ☐



1 0In β^- decay:**[1 mark]****A** energy is conserved.☒**B** an up quark changes into a down quark.☐**C** the interaction occurs outside the nucleus of an atom.☐**D** momentum is not conserved.☐**1 1**A force F moves through a distance x in the direction of F .

In which row is the work done by the force 1 J?

[1 mark]

	F	x	
A	1 mN	1 km	☒
B	100 kN	100 μm	☐
C	100 MN	100 nm	☐
D	1 GN	1 fm	☐

1 2

In a photoelectric effect experiment, monochromatic light is incident on a metal surface and the stopping potential is measured.

Which change results in a greater stopping potential?

[1 mark]**A** using a metal that has a greater work function☐**B** using a light source that emits more photons per second☐**C** using a light source that emits light of a shorter wavelength☒**D** using a metal surface that has a positive charge☐**Turn over ►**

- 1 3** Which row provides evidence for the particle nature of light and the wave nature of light? **[1 mark]**

	Evidence for particle nature	Evidence for wave nature	
A	line spectra	photoelectric effect	☐
B	diffraction	line spectra	☐
C	photoelectric effect	diffraction	☒
D	photoelectric effect	line spectra	☐

- 1 4** In an investigation of stationary waves on different wires, the frequency f of the first harmonic is measured.

Which quantity produces a straight-line graph through the origin when plotted against f ?
In each case all other variables are kept constant.

[1 mark]

- A** $\frac{1}{\text{diameter of the wire}}$ ☒
- B** (mass per unit length of the wire)² ☐
- C** length of the wire ☐
- D** (tension in the wire)² ☐

- 1 5** A student derives the equation $n\lambda = d\sin\theta$ for the production of a diffraction pattern on a screen.
This derivation requires that:

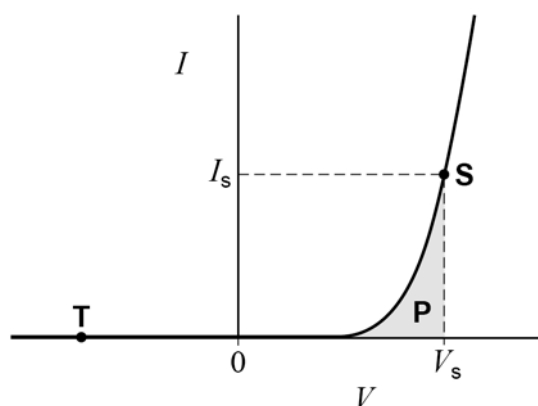
[1 mark]

- A** the diffraction angle θ is a small angle. ☐
- B** d is the number of slits per unit length. ☐
- C** light from adjacent slits arrives at the screen in phase. ☒
- D** $n\lambda$ is greater than or equal to d , where n is a whole number. ☐



1 6

The graph shows the I – V characteristic for a semiconductor diode.



Which is true for this graph?

[1 mark]

A The resistance of the diode decreases as V increases for $V > V_s$.

☒

B The resistance at **S** is equal to $\frac{1}{\text{gradient}}$

☐

C The resistance at **T** is equal to zero.

☐

D At $I = I_s$, the power dissipated in the diode is equal to area **P**.

☐

1 7

Monochromatic light of wavelength λ is used in a double-slit experiment.

The slits are vertical and have a separation s .

A narrow screen of width Y is placed a distance D from the slits.

Which gives the number of fringes observed on the screen?

[1 mark]

A $\frac{\lambda D}{sY}$

☐

B $\frac{\lambda s}{DY}$

☐

C $\frac{DY}{s\lambda}$

☐

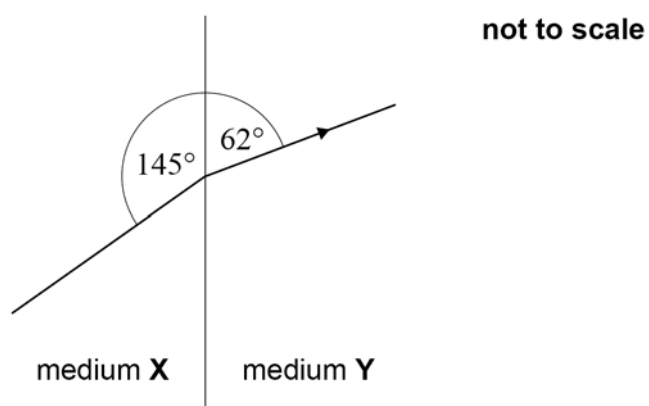
D $\frac{Ys}{\lambda D}$

☒

Turn over ►



- 1 8** A light ray passes from medium **X** to medium **Y**.



The refractive index of **X** is 1.33

What is the refractive index of **Y**?

[1 mark]

- A** 0.86 ☐
- B** 1.22 ☐
- C** 1.74 ☐
- D** 2.32 ☒

- 1 9** The critical angle at a boundary between two media is 53° .
The speed of light in one medium is $2.6 \times 10^8 \text{ m s}^{-1}$.

What is the speed of light in the other medium?

[1 mark]

- A** $1.6 \times 10^8 \text{ m s}^{-1}$ ☐
- B** $2.1 \times 10^8 \text{ m s}^{-1}$ ☒
- C** $3.0 \times 10^8 \text{ m s}^{-1}$ ☐
- D** $3.2 \times 10^8 \text{ m s}^{-1}$ ☐



2 0

Monochromatic light of wavelength 420 nm is incident normally on a plane transmission diffraction grating that has a slit separation of $3.6 \mu\text{m}$.

What is the total number of maxima produced by the grating?

[1 mark]

A 8 ☐

B 9 ☐

C 16 ☐

D 17 ☒

2 1

A skydiver is falling at a terminal velocity v_1 .

When she is at a height h_1 she opens her parachute.

When she is at a height h_2 she reaches a new terminal velocity v_2 .

Which is true?

[1 mark]

A The increased air resistance when her height is h_1 causes her initially to move upwards. ☐

B The drag force when her velocity is v_2 is equal to the drag force when her velocity is v_1 . ☒

C At v_1 , her weight and the drag force are an action–reaction pair according to Newton’s third law. ☐

D Between h_1 and h_2 , the work done by the drag force is equal to the change in the kinetic energy of the parachute and skydiver. ☐

Turn over for the next question

Turn over ►



2 2 The work function of a metal is ϕ .

A photon with an energy of $3.8 \times 10^{-19} \text{ J}$ is incident on the metal surface.

Electrons are emitted from the surface with a maximum speed of $2.5 \times 10^5 \text{ m s}^{-1}$.

What is ϕ ?

[1 mark]

A $0.29 \times 10^{-19} \text{ J}$ ☐

B $3.5 \times 10^{-19} \text{ J}$ ☒

C $3.8 \times 10^{-19} \text{ J}$ ☐

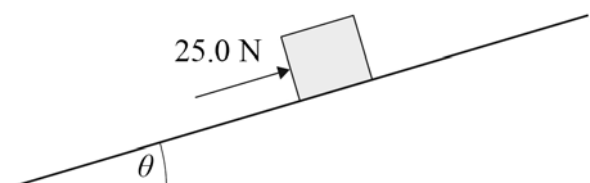
D $4.1 \times 10^{-19} \text{ J}$ ☐

2 3 A ramp is inclined at an angle θ to the horizontal.

A block of weight 240 N is pushed up the ramp by a 25.0 N force. This force acts parallel to the ramp.

The block experiences a frictional force of 3.0 N .

The block moves at a constant speed.



What is θ ?

[1 mark]

A 0.12° ☐

B 5.3° ☒

C 6.0° ☐

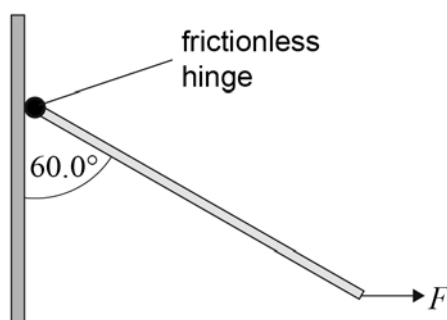
D 6.7° ☐



2 4

A uniform wooden rod of mass 0.55 kg and length 1.3 m is attached to a wall by a light frictionless hinge.

A horizontal force F acts so that the rod hangs at an angle of 60.0° to the vertical.



What is the magnitude of F ?

[1 mark]

A 0.95 N ☐

B 1.6 N ☐

C 2.7 N ☐

D 4.7 N ☒

2 5

A pendulum is oscillating with simple harmonic motion.

Which row gives the momentum of the pendulum bob and its gravitational potential energy (GPE) when the acceleration of the pendulum bob is zero?

[1 mark]

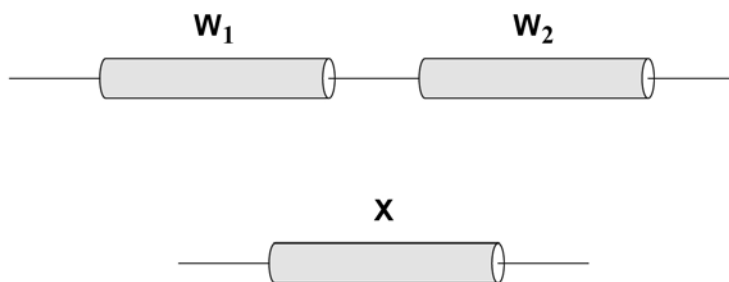
	Momentum	GPE	
A	zero	maximum	☐
B	maximum	minimum	☒
C	maximum	maximum	☐
D	zero	minimum	☐

Turn over ►



2 6

Two thin metal rods W_1 and W_2 , each of length L and diameter d , are connected in series.



The resistivity of W_1 is ρ_1 and the resistivity of W_2 is ρ_2 .

A single metal rod X , also of length L and diameter d , has the same resistance as the series combination of W_1 and W_2 .

What is the resistivity of X ?

[1 mark]

A $\rho_1 + \rho_2$ ☒

B $\frac{\rho_1 + \rho_2}{2}$ ☐

C $\frac{\rho_1 + \rho_2}{\rho_1 \rho_2}$ ☐

D $\frac{\rho_1 \rho_2}{\rho_1 + \rho_2}$ ☐

2 7

An alpha particle has a speed of $4.5 \times 10^5 \text{ m s}^{-1}$.

What is the de Broglie wavelength of the alpha particle?

[1 mark]

A $2.2 \times 10^{-13} \text{ m}$ ☒

B $4.4 \times 10^{-13} \text{ m}$ ☐

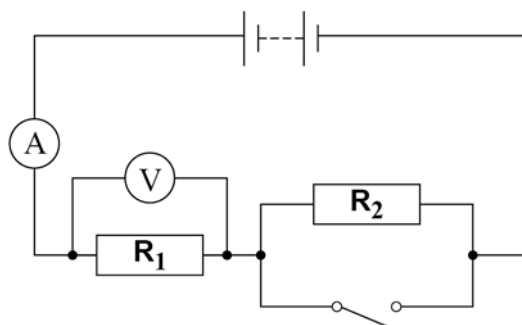
C $8.8 \times 10^{-13} \text{ m}$ ☐

D $3.9 \times 10^{-12} \text{ m}$ ☐



2 8

In a circuit, the resistance of resistor R_1 is double the resistance of resistor R_2 .
The internal resistance of the battery is negligible.



When the switch is open, the voltmeter reads 12 V and the ammeter reads 12 mA.

What are the readings on the voltmeter and ammeter when the switch is closed?

[1 mark]

	Voltmeter reading / V	Ammeter reading / mA
A	4	12
B	18	12
C	18	18
D	24	24

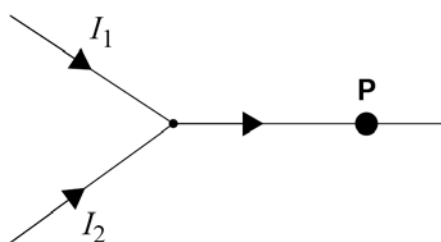
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☐
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Turn over for the next question

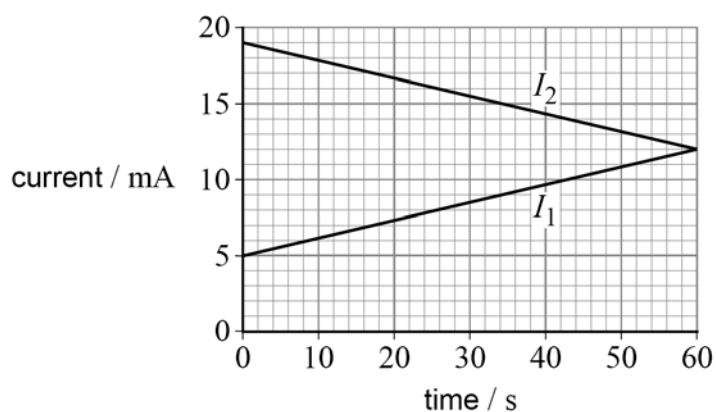
Turn over ►



2 9 The diagram shows part of a circuit.



The graph shows how the two currents I_1 and I_2 vary with time.



What is the total charge that flows through point **P** in 60 s?

[1 mark]

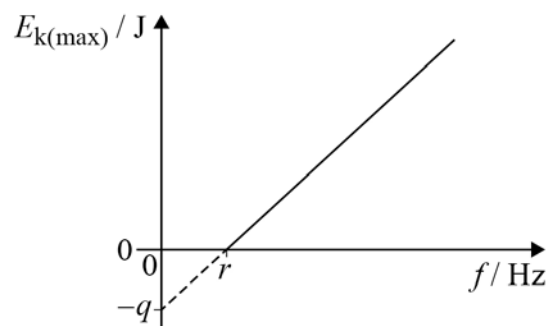
- A** 1.44 C ☒
- B** 0.93 C ☐
- C** 0.72 C ☐
- D** 0.42 C ☐

3 0

In a photoelectric experiment, the maximum kinetic energy $E_{k(\max)}$ of the emitted electrons and the frequency f of the incident radiation are measured.

A graph of the variation of $E_{k(\max)}$ with f has:

- a gradient p
- an intercept $-q$ on the $E_{k(\max)}$ axis
- an intercept r on the f axis.



What is the value of the Planck constant?

[1 mark]

A $\frac{p}{r}$ ☐

B $\frac{r}{p}$ ☐

C $\frac{r}{q}$ ☐

D $\frac{q}{r}$ ☒

Turn over for the next question

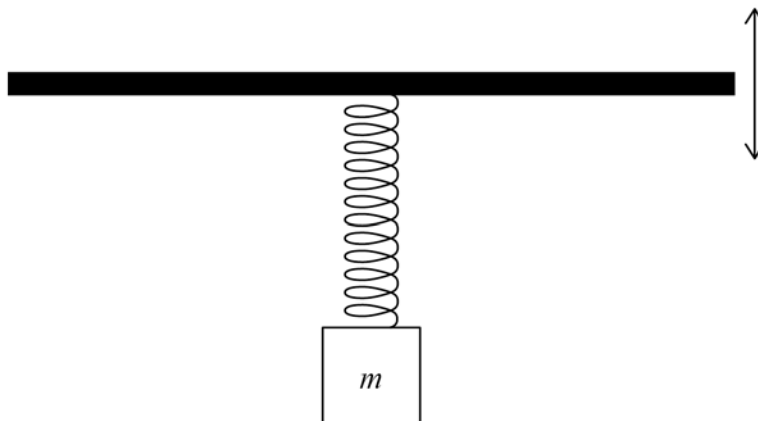
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3 1

A spring with a spring constant of 50 N m^{-1} is attached to a rigid horizontal bar. An object of mass m is attached to the bottom of the spring.

When the bar is made to move vertically up and down with a frequency of 2.6 Hz , the mass–spring system undergoes resonance. Ignore the effects of damping.



What is m ?

[1 mark]

A 190 g ☒

B 370 g ☐

C 490 g ☐

D 590 g ☐

3 2

A simple pendulum of length 8.0 cm oscillates on Earth with a frequency f_1 .

An identical pendulum on the Moon oscillates with a frequency f_2 .

The acceleration due to gravity is 1.6 m s^{-2} on the surface of the Moon.

What is $f_1 - f_2$?

[1 mark]

A 1.8 Hz ☐

B 1.1 Hz ☒

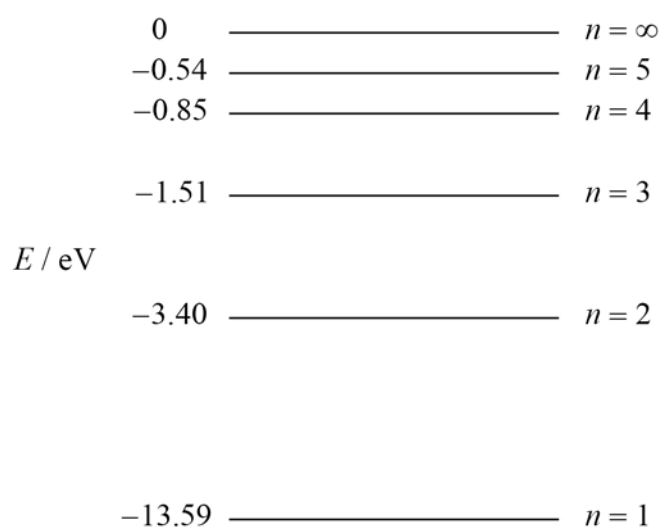
C 0.85 Hz ☐

D 0.35 Hz ☐



3 3

The diagram shows some of the energy levels for a hydrogen atom.



Photons of energy 12.74 eV excite hydrogen atoms that are all initially in the ground state ($n = 1$).

How many different photon frequencies are emitted as the atoms return to their ground state?

[1 mark]

- A** 3 ☐
- B** 5 ☐
- C** 6 ☒
- D** 9 ☐

25

END OF QUESTIONS



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ANSWER IN THE SPACES PROVIDED**



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