AQA

Please write clearly in block capitals.

Centre number | 9 | 1 | 0 | 9 | 3 | Candidate number | 8 | 3 | 7 | 0 |

Surname Matheson

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Candidate signature

I declare this is my own work.

A-level PHYSICS

Paper 1

A Level Physics Online . com

Friday 24 May 2024 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	
8–32	
TOTAL	

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Section A

Answer **all** questions in this section.

0 1 . 1 State the names of the four fundamental interactions.

[1 mark]

1 Gravity

2 Electromagnetic

3 Strong

4 Weak ✓

0 1 . 2 State the products of the decay of a free neutron.

[1 mark]

Proton, electron, antineutrino ✓ $n \rightarrow p + e^- + \bar{\nu}_e$

0 1 . 3 Explain which of the fundamental interactions is responsible for the decay of the neutron.

[2 marks]

Weak interaction ✓. It involves leptons ∴ can't be strong interaction and involves changing quark flavour. ✓

0 1 . 4 The forces between two moving electrons cause their paths to change.

Explain, using the concept of exchange particles, why the electron paths change.

[3 marks]

The exchange particle is a virtual photon ✓ which has momentum. Momentum must be conserved ✓ ∴ momentum of electron changes as photon exchanged between them ∴ the path changes. ✓

7

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0 2 A positive pion collides with a neutron and the following interaction is observed:

$$\pi^+ + n \rightarrow K^+ + \Sigma^0$$

Σ^0 is a neutral sigma particle with a strangeness of -1

The interaction can be used to deduce the classifications of the Σ^0.

0 2 . 1 Identify the classifications of each particle in **Table 1**.
Tick (✓) the appropriate boxes for each particle.

[2 marks]

Table 1

Particle	Baryon	Hadron	Lepton	Meson
π^+		✓		✓
n	✓	✓		
K^+		✓		✓
Σ^0	✓	✓		

✓✓

0 2 . 2 A conservation rule predicts that the following interaction **cannot** occur:

$$\pi^- + n \rightarrow K^- + \Sigma^0$$

State the conservation rule.
Go on to explain your answer.

[3 marks]

Q -1 0 → -1 0
B 0 +1 → 0 +1
S 0 0 → -1 -1 = -2 ✓

Strangeness has not been conserved ✓, therefore the interaction cannot occur, as this is a strong interaction where strangeness is conserved. ✓

Question 2 continues on the next page

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One way in which neutral pions decay is

$$\pi^0 \rightarrow e^- + e^+ + \gamma$$

0 2 . 3 Compare the rest energies of the particles involved in this decay.

[2 marks]

π^0 $E_0 = 134.972$ MeV

e^- & e^+ $E_0 = 0.510999$ MeV

γ, $E_0 = 0$ ✓

The rest energy of the pion is much greater than that of the e^-, e^+ and photon combined. ✓

0 2 . 4 The decay of the neutral pion leads to the production of further gamma photons.

Explain why.

[1 mark]

The electron and positron annihilate. ✓

0 2 . 5 The Standard Model is a theory that classifies elementary particles. Evidence for the theory has been collected since about 1950. However, the term Standard Model has only been used since 1973.

Suggest why progress in particle physics is slow.

[1 mark]

International collaboration is required, which is complex. ✓

9

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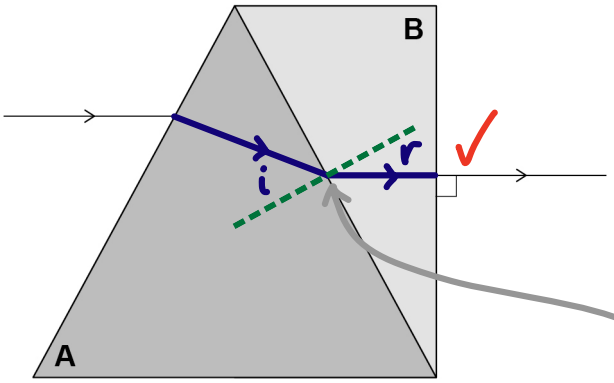
0 3 **Figure 1** shows two prisms **A** and **B** of different refractive indices joined to make a block.
A ray of monochromatic light is shown entering and then leaving the block.

Figure 1



0 3 . 1 Complete, on **Figure 1**, the path of the ray of light inside the block.

[1 mark]

0 3 . 2 Deduce which prism, **A** or **B**, has the greater refractive index.

[2 marks]

B has a greater refractive index, because at the boundary of AB, the light bends towards the normal. $i > r$ $\therefore n_B > n_A$

The block is used with a telescope to investigate stars.
The block can be replaced with a diffraction grating.

0 3 . 3 Describe **one** non-astronomical application of a diffraction grating.

[1 mark]

To analyse the chemical composition of a sample.

Question 3 continues on the next page

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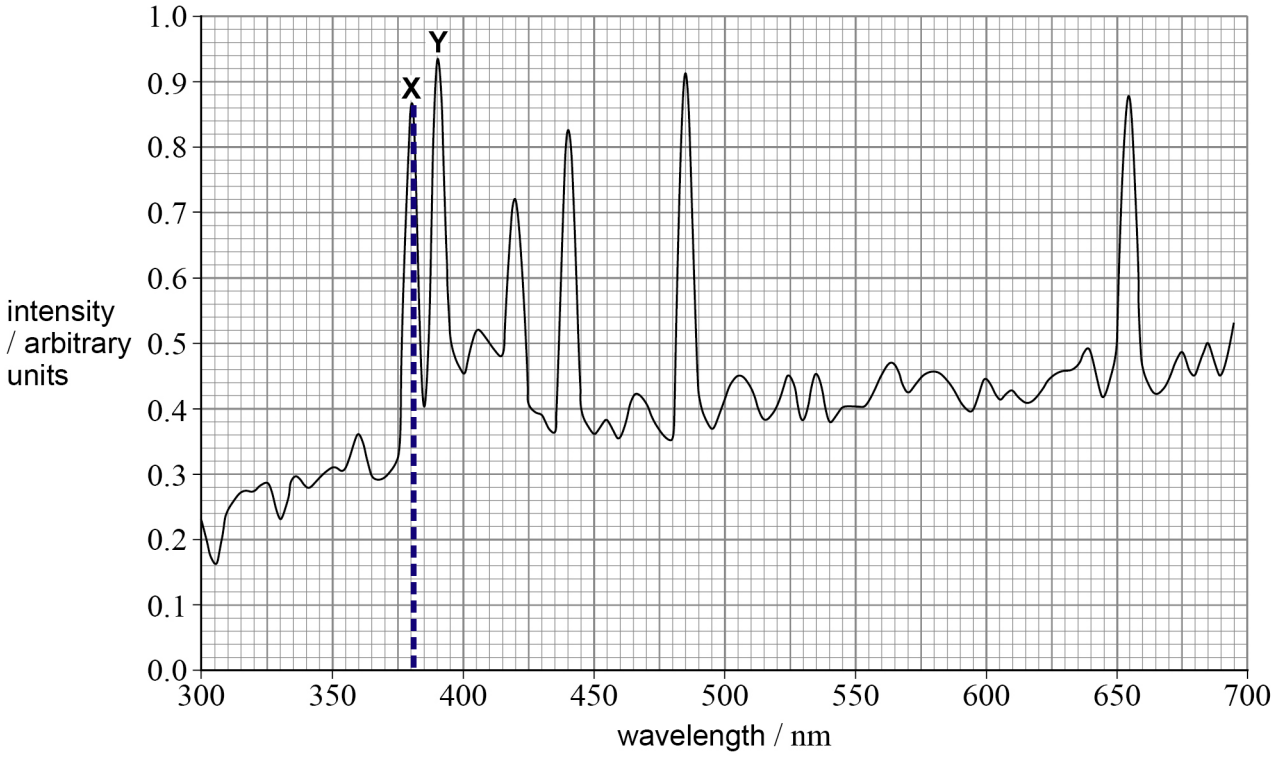
0 3 . 4 **Figure 2** shows a spectrum of light. Two lines in the spectrum are labelled **X** and **Y**.

Figure 2



The light passes at normal incidence through a diffraction grating. The number of lines per metre for the grating is G.

The first-order diffraction angle of **X** is at $28.2°$ to the normal.

Calculate G.

[3 marks]

$\lambda = 380\,nm \qquad \theta = 28.2° \qquad n = 1$

$n\lambda = d \sin\theta$

$d = \frac{n\lambda}{\sin\theta} = \frac{1 \times 380 \times 10^{-9}}{\sin 28.2} = 8.041 \times 10^{-7}\ m$ ✓

$G = \frac{1}{d} = \frac{1}{8.041 \times 10^{-7}} = 1.244 \times 10^{6}$ ✓

$G =$ 1.2 x10^6 ✓ m^{-1}

Do not write outside the box

0 3 . 5 A scientist wants to obtain an accurate value for the difference in wavelength between line **X** and line **Y**.

She has two options:

- option 1: to analyse the second-order spectrum from the original grating
- option 2: to analyse the first-order spectrum from a grating with $2G$ lines per metre.

Discuss which option she should choose.

[3 marks]

$n\lambda = d\sin\theta = \frac{\sin\theta}{G}$ $\therefore \sin\theta = n\lambda G$ ✓

If $n=2$ or $G \rightarrow 2G$, both increase $\sin\theta$ by a factor of 2 ∴ same outcome for both option 1 and option 2. ✓

It would be better to use a diffraction grating with $2G$ lines, as the 2nd order maxima may overlap with other orders, obscuring the absorption lines. ✓

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Turn over for the next question

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0 4 The deuterium–tritium (D–T) reaction is a nuclear reaction between two isotopes of hydrogen.
The D–T reaction is

$$^{2}_{1}\mathrm{H} + ^{3}_{1}\mathrm{H} \rightarrow ^{4}_{2}\mathrm{He} + \mathrm{n}$$

The energy from this reaction is transferred to the kinetic energy of the helium nucleus and the kinetic energy of the neutron.
Assume that the kinetic energies of the hydrogen nuclei are zero just before the reaction occurs.

0 4 . 1 Show that the kinetic energy of the neutron represents approximately 80% of the total energy transferred.

[2 marks]

$E_K = \frac{p^2}{2m}$ p is constant (conserved)

$\therefore$ The same size p for both, $E_K \propto \frac{1}{m}$

$m_{He} \approx 4 m_n$ $\therefore$ $E_{K_{He}} = \frac{1}{4} E_{K_n}$ ✓

$E_{K_{He}} : E_{K_n} \rightarrow \frac{1}{4} E_{K_n} : E_{K_n} \rightarrow 1:4 \rightarrow 20:80$ ✓

80% of total

0 4 . 2 The combined kinetic energy of the helium nucleus and the neutron is 2.82×10^{-12} J.

Calculate the initial speed of the neutron.

[2 marks]

$0.80 \times 2.82 \times 10^{-12} = 2.256 \times 10^{-12}\ \mathrm{J} = \frac{1}{2} m v^2$

$v = \sqrt{\frac{2 \times 2.256 \times 10^{-12}}{1.675 \times 10^{-27}}} = 5.190 \times 10^{7}$ ✓

initial speed = 5.2 × 10^7 ✓ m s^{-1}

4

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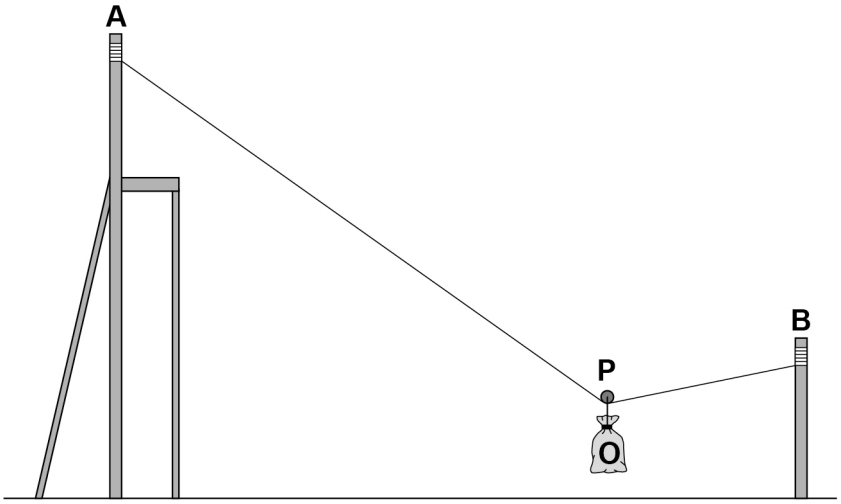
0 5 A cable system is to be used to transfer supplies across a river. A model of the proposed system is built in order to test its performance.

The model consists of a cable attached to two vertical posts **A** and **B**, as shown in **Figure 3**.
A pulley **P** of negligible mass is attached to the cable.

In this question the length of the cable does not change and the weight of the cable can be ignored.

Figure 3



An object **O** is attached to **P**. In one test, **O** and **P** are at rest in the position shown in **Figure 3**.
The weight of **O** is $350\ \mathrm{N}$.

Question 5 continues on the next page

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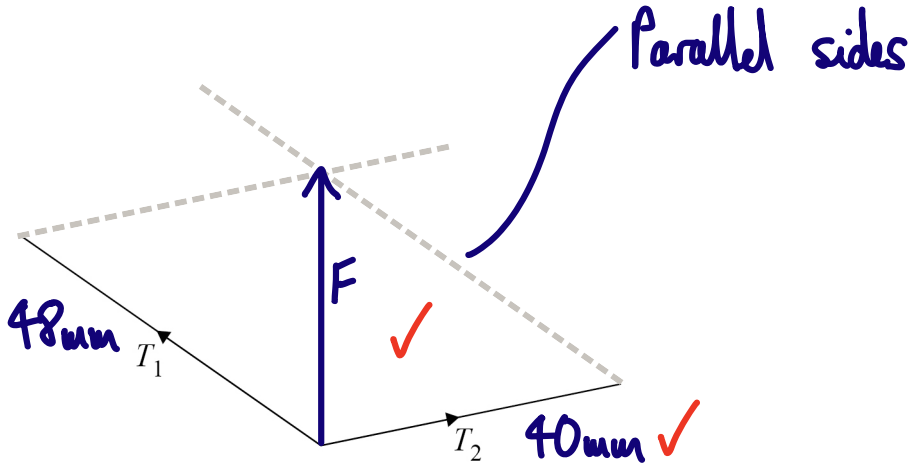
0 5 . 1 **Figure 4** is a force diagram drawn to scale. It represents the magnitudes and directions of the tensions T_1 and T_2 in the cable when **O** is at rest in the position shown in **Figure 3**. At this position, resistive forces are zero.

Complete the force diagram.
Go on to determine, using your diagram, the magnitudes of T_1 and T_2.

[4 marks]

Figure 4



$F = W$

$W = 350\ N$ and $35mm$

$\therefore 1mm = 10\ N$

$T_1 = 48 \times 10 = 480\ N$

$T_2 = 40 \times 10 = 400\ N$

$T_1 =$ 480 N

$T_2 =$ 400 N

Do not write outside the box

0 5 . 2 In a second test, pulley **P** with **O** attached is released from **A**.
P and **O** move along the cable to **B**.

The change in height of the centre of mass of **O** between **A** and **B** is $4.5\ \text{m}$.
The distance travelled along the cable is $18\ \text{m}$.

The speed of **O** when it reaches **B** is $6.5\ \text{m s}^{-1}$.

Calculate the average resistive force on **O** and **P** as they move from **A** to **B**.

[5 marks]

$W = mg \quad m = \frac{W}{g} = \frac{350}{9.81} = 35.68\ \text{kg}$ ✓

Work done against friction = $\Delta E_p - E_K$ ✓

$W = mgh - \frac{1}{2}mv^2 = m\left(gh - \frac{v^2}{2}\right)$

$W = 35.68\left((9.81 \times 4.5) - \left(\frac{6.5^2}{2}\right)\right)$ ✓

$W = 821.3\ \text{J}$

$W = Fs \quad F = \frac{W}{s} = \frac{821.3}{18} = 45.6$ ✓

average resistive force = 46 ✓ N

Question 5 continues on the next page

Do not write outside the box

0 5 . 3 **O** contains a fragile item packed in suitable material.

Explain how the material can prevent damage to the fragile item when **O** stops suddenly at **B**.

[3 marks]

As the force is proportional to the rate of change of momentum ✓, by increasing the collision time the force on the item decreases ✓ (for the same change in momentum). This means that it will less likely to break if a soft material is used to increase the collision time. ✓

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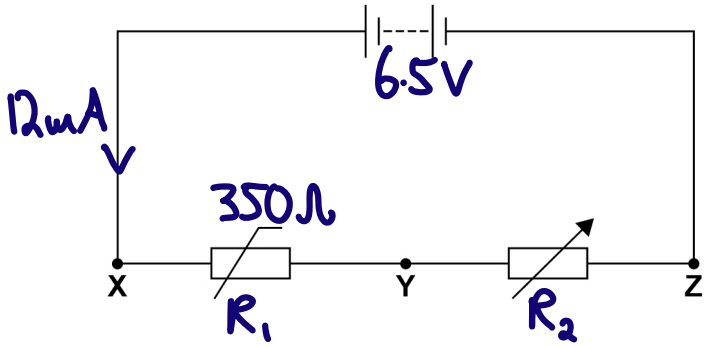
0 6 The circuit in **Figure 5** is used as part of a temperature sensor.
The battery has an emf of 6.5 V and negligible internal resistance.

Figure 5



The initial temperature of the thermistor is 22 °C.
At this temperature the resistance of the thermistor is 350 Ω and the circuit current is 12 mA.

0 6 . 1 Calculate the resistance of the variable resistor.

[2 marks]

$V = IR \quad R_T = \frac{V}{I} = \frac{6.5}{12 \times 10^{-3}} = 541.7\ \Omega$ ✓

$R_2 = R_T - R_1 = 541.7 - 350 = 191.7$

resistance = 190 ✓ Ω

Question 6 continues on the next page

Do not write outside the box

0 6 . 2 The resistance R of the thermistor at temperature θ in K is given by:

$$R = R_0 e^{B\left(\frac{1}{\theta} - \frac{1}{\theta_0}\right)}$$

where R_0 is the resistance at the initial temperature θ_0 in K, and B is a constant.

The temperature of the thermistor is increased to 318 K.
The variable resistor is adjusted so that the circuit current is again 12 mA.
The potential difference across the thermistor is now 3.2 V.

Determine B.
State an appropriate unit for your answer.

[5 marks]

$\theta_0 = 22 + 273 = 295\,K$ ✓ $R_0 = 350\,\Omega$

At 318K, $\theta = 318\,K$

$R = \frac{V}{I} = \frac{3.2}{12\times10^{-3}} = 266.667\,\Omega$ ✓

$R = R_0 e^{B\left(\frac{1}{\theta} - \frac{1}{\theta_0}\right)}$

$\ln(R/R_0) = B\left(\frac{1}{\theta} - \frac{1}{\theta_0}\right)$

$B = \frac{\ln(266.7/350)}{\frac{1}{318} - \frac{1}{295}} = 1109.1$ ✓

as $\ln(R/R_0)$ is unitless, $B = \frac{1}{1/K}$

$B =$ 1100 ✓ unit = K ✓

Do not write outside the box

0 6 . 3 Explain why the current in the thermistor needs to be controlled.

[2 marks]

The current causes a heating effect in the circuit. ✓ For the circuit to act as a temperature sensor, the temperature of the circuit needs to remain constant, (so the change in external temperature ✓ changes the resistance of the thermistor).

0 6 . 4 Explain how ammeters and voltmeters can be used in the circuit in **Figure 5** to demonstrate the conservation of charge and the conservation of energy.

Refer to points **X**, **Y** and **Z** in your answer.

[2 marks]

Demonstrate the conservation of charge by connecting an ammeter at X, Y and Z. In series, the current should be the same at each point. ✓
Connect a voltmeter between X and Y, Y and Z and X and Z. This will show that the EMF (X-Z) is equal to the sum of the PDs (X-Y + Y-Z), which means the energy per unit charge is conserved. ✓

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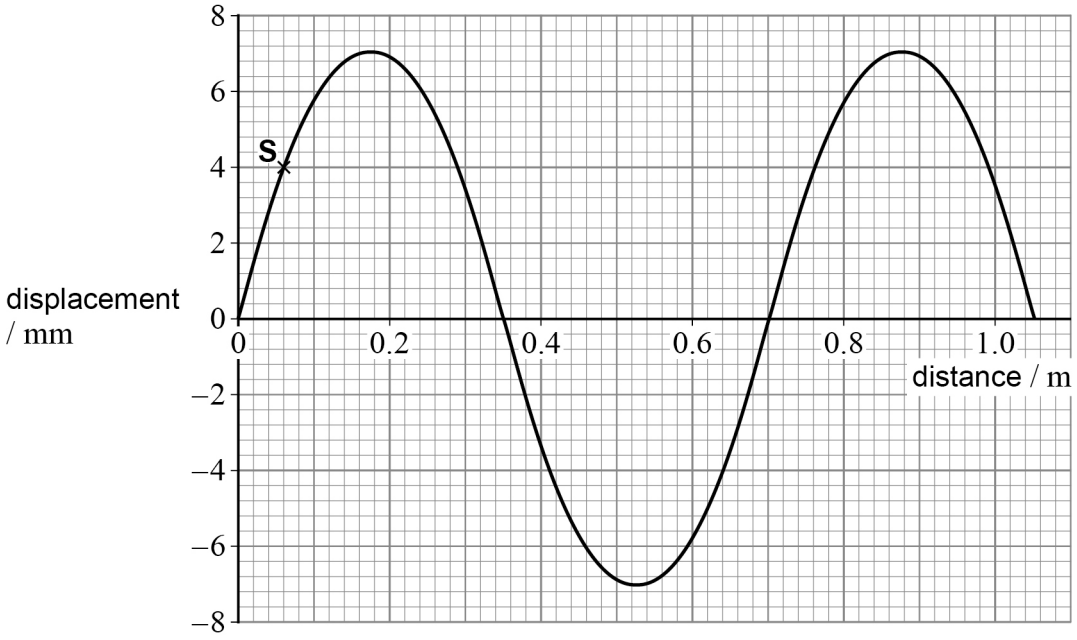
Do not write outside the box

0 7 An experiment is done to investigate stationary waves on a string.
A string of length 1.05 m is attached between a clamp stand and a vibration generator. A stationary wave is formed on the string when the vibration generator frequency is 625 Hz.

Figure 6 shows the variation of displacement with distance from one end of the string at time $t = 0$
At this time all points on the string have their maximum displacement.
S is one point on the string.

Figure 6



The stationary wave is produced by two progressive waves travelling in opposite directions on the string.

0 7 . 1 Deduce the amplitude of one of the progressive waves.

[1 mark]

$A_T = A_p + A_p$ (Progressive)

(Total) $A_T \approx 7.0\text{ mm} = 2A_p$ $A_p = 3.5$

amplitude = 3.5 ✓ mm

Do not write outside the box

0 7 . 2 Determine, in $\mathrm{m\ s^{-1}}$, the speed of one of the progressive waves.

[2 marks]

$v = f\lambda = 625 \times 0.70 = 437.5$ ✓

speed = 4.4×10^2 ✓ $\mathrm{m\ s^{-1}}$

0 7 . 3 State the phase relationship between the two waves when $t = 0$

[1 mark]

In phase ✓

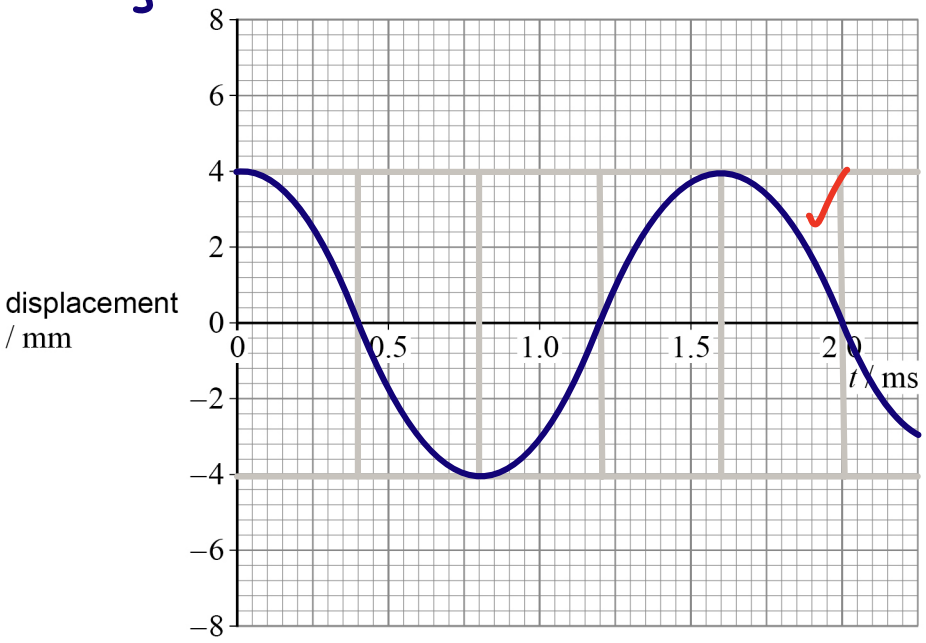
0 7 . 4 Sketch, on **Figure 7**, a graph to show how the displacement of **S** varies with t.

[3 marks]

$x_{max} = 4.0\ \mathrm{mm}$ ✓

Figure 7

$T = 1/f = 1/625 = 1.6\ \mathrm{ms}$ ✓



✓

END OF SECTION A

7

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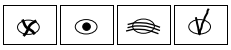
Section B

Each of Questions **08** to **32** 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 8 Which nuclear change results in the nucleus with the greatest specific charge?

[1 mark]

A the alpha decay of a $^{209}_{82}\mathrm{Po}$ nucleus ⬭ 80/205 = 0·39

B the beta-minus decay of a $^{28}_{12}\mathrm{Mg}$ nucleus ⬭ 13/28 = 0·46

C the beta-plus decay of a $^{39}_{20}\mathrm{Ca}$ nucleus ● ✓ 19/39 = 0·49

D electron capture by a $^{105}_{47}\mathrm{Ag}$ nucleus ⬭ 46/105 = 0·44

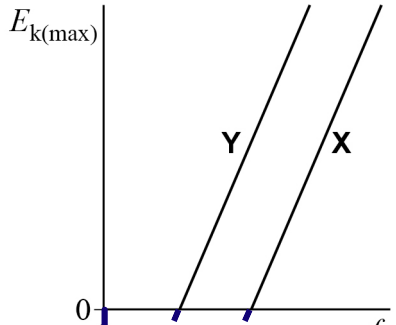
Do not write outside the box

0 9 In two separate experiments, electromagnetic radiation of variable frequency f is incident on the surfaces of plates made from metals **X** and **Y**.
The work function of **X** is greater than the work function of **Y**.

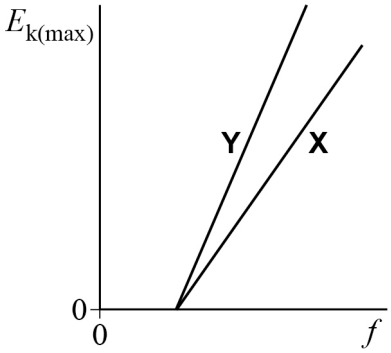
Which graph shows how the maximum kinetic energy $E_{k(max)}$ of photoelectrons emitted from the surfaces of the plates varies with f?

[1 mark]

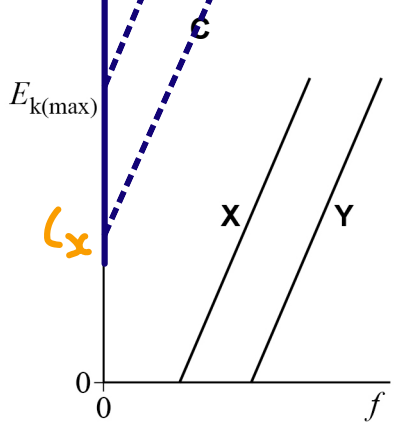
A



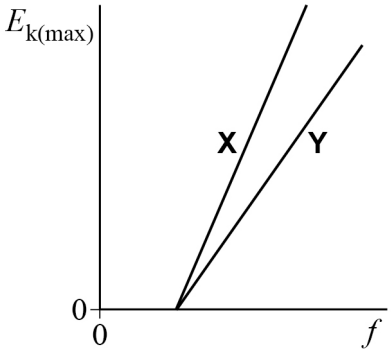
B



C



D



A ✓

B

C

D

$hf = \phi + E_{k(max)}$

$E_{k(max)} = hf - \phi$

$y = mx + c$

$\therefore$ gradient = h = same

$\phi_x > \phi_Y \therefore C_x$ more negative

Turn over ►

Do not write outside the box

1 0 Monochromatic light is incident on a metal surface in a vacuum and photoelectrons are emitted from the surface. The photoelectric current I is the rate of flow of charge from the surface.
The maximum kinetic energy of the photoelectrons is $E_{k(max)}$.
$E_{k(max)}$ and I are measured.

The frequency of the light is then increased. There is no change to the rate at which energy is incident on the surface.

What happens to $E_{k(max)}$ and I when the frequency is increased?

[1 mark]

	$E_{k(max)}$	I	
A	increases	decreases	⬬ ✓
B	increases	no change	⬭
C	no change	no change	⬭
D	no change	decreases	⬭

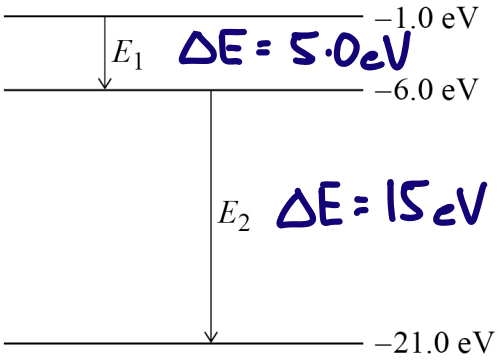
$E_{k(max)} = hf - \phi$

$f \uparrow \therefore E_k \uparrow$

Total energy per second stays the same.
Energy per photon increases ∴ no. of photons per second decreases ∴ I decreases.

Do not write outside the box

1 1 Three energy levels for an atom are shown.



Energy change E_1 leads to the emission of a photon of wavelength λ_1.
Energy change E_2 leads to the emission of a photon of wavelength λ_2.

What is $\frac{\lambda_1}{\lambda_2}$?

$E = \frac{hc}{\lambda}$ $E \propto \frac{1}{\lambda}$

[1 mark]

A $\frac{1}{4}$ ⬭

B $\frac{1}{3}$ ⬭

C 3 ⬬ ✓

D 4 ⬭

$\frac{\lambda_1}{\lambda_2} = \frac{E_2}{E_1} = \frac{15}{5} = 3$

1 2 An electron and a proton move with the same speed.

What is $\frac{\text{de Broglie wavelength of electron}}{\text{de Broglie wavelength of proton}}$?

[1 mark]

A 5.5×10^{-4} ⬭

B 2.3×10^{-2} ⬭

C 42 ⬭

D 1800 ⬬ ✓

$\lambda = \frac{h}{mv}$

$\frac{\lambda_e}{\lambda_p} = \frac{m_p}{m_e} = \frac{1.673 \times 10^{-27}}{9.11 \times 10^{-31}} = 1836$

Do not write outside the box

1 3 A laser emits light of wavelength 600 nm for 10 ns.

What is the number of complete waves emitted by the laser?

[1 mark]

A 5×10^{17} ⬭

B 5×10^{12} ⬭

C 5×10^{8} ⬭

D 5×10^{6} ⬬ ✓

$v = f\lambda = \frac{\lambda}{T}$

$T = \frac{\lambda}{v} = \frac{600 \times 10^{-9}}{3.00 \times 10^{8}} = 2.00 \times 10^{-15}$

$t/T = 10 \times 10^{-9} / 2.00 \times 10^{-15} = 5.0 \times 10^{6}$

1 4 A detector measures the intensity of light from a source S_1.
Polaroid material is placed between source S_1 and the detector. When the material is rotated through a small angle, the detected intensity does not change.
When this procedure is repeated for a source S_2, the detected intensity decreases.

Which is correct?

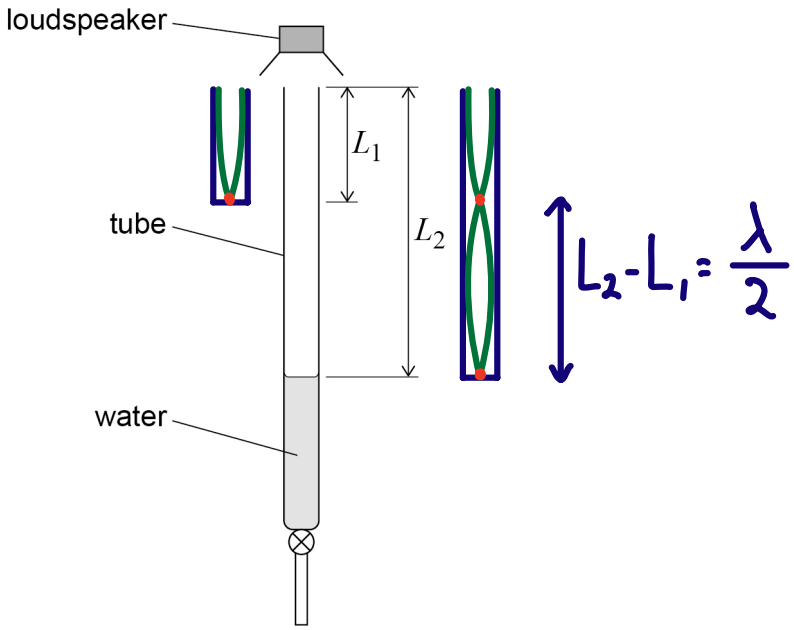
[1 mark]

	Light waves from S_1	Light waves from S_2	
A	unpolarised	polarised	⬬ ✓
B	unpolarised	unpolarised	⬭
C	polarised	polarised	⬭
D	polarised	unpolarised	⬭

No change ⟶ Unpolarised

Change ⟶ Polarised

1 5 A loudspeaker producing a single-frequency sound is mounted above a tube filled with water. A tap at the bottom of the tube is opened to allow the water to run out.



A student observes the change in loudness of the sound emitted by the tube as the water runs out.

When the length of the column of air in the tube reaches L_1, the loudness is at its first maximum.

The next maximum is reached when the length of the column of air is L_2.

What is the wavelength of the sound emitted by the loudspeaker?

[1 mark]

A L_2

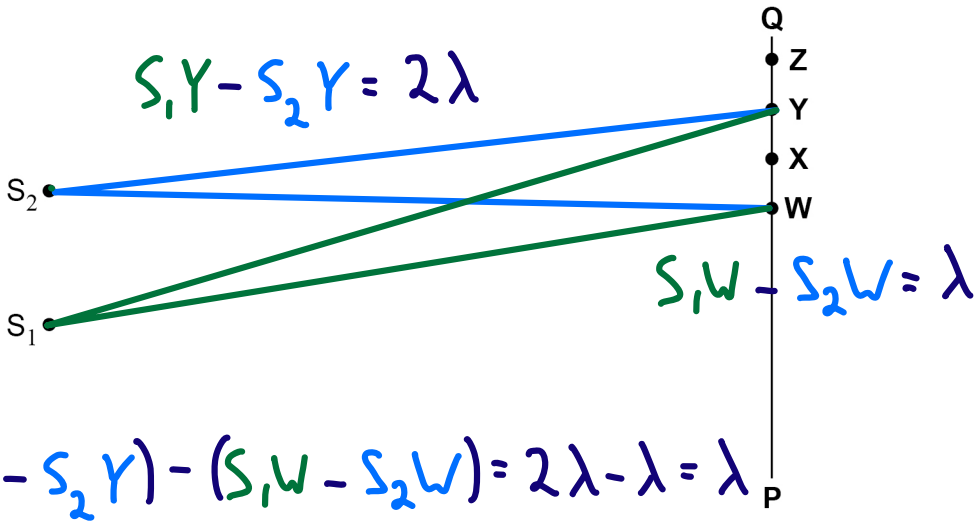
B $2L_1$

C $L_2 - L_1$

D $2(L_2 - L_1)$ ✓

Do not write outside the box

1 6 Point sources of sound of the same frequency are placed at S_1 and S_2.



A sound detector is moved slowly along the line **PQ**. Consecutive maxima of sound intensity are detected at **W** and **Y** and consecutive minima are detected at **X** and **Z**.

What is the wavelength of the sound?

[1 mark]

A $(S_1Y–S_2Y) – (S_1W–S_2W)$ ✓

B $(S_1X–S_2X) – (S_1W–S_2W)$

C $(S_1Y–S_2Y) – (S_1X–S_2X)$

D $(S_1Z–S_2Z) – (S_1W–S_2W)$

1 7 Monochromatic light is used in a Young's double-slit interference experiment after passing through a single slit. The resulting fringe pattern is observed on a screen.

The separation of the fringes can be increased by $w = \frac{\lambda D}{s}$

[1 mark]

A using monochromatic light of lower frequency. $\lambda \uparrow \therefore w \uparrow$ ✓

B decreasing the width of the single slit.

C increasing the separation of the double slits.

D decreasing the distance between the double slits and the screen.

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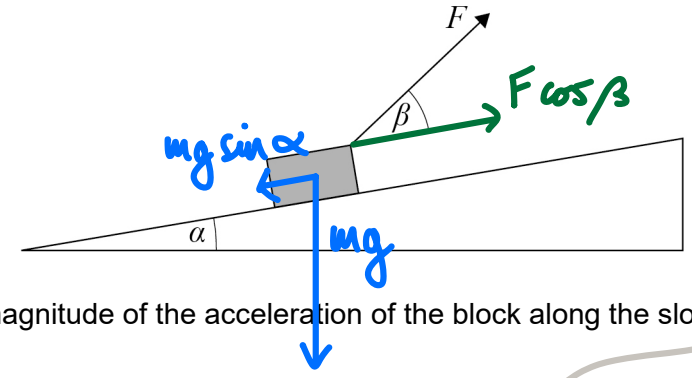
1 8 A force of magnitude F acts on a box of mass m that moves along a frictionless slope. The slope is at an angle α to the horizontal and the force acts at an angle β to the slope.



Resultant force

What is the magnitude of the acceleration of the block along the slope?

[1 mark]

A $\frac{F}{m}\sin\alpha - g\sin\beta$ ⬭

B $\frac{F}{m}\cos\beta - g\sin\alpha$ ⬬ ✓

C $\frac{F}{m}\cos(\alpha+\beta) - g\cos\beta$ ⬭

D $\frac{F}{m}\cos(\alpha+\beta) - g\sin\beta$ ⬭

$F_R = ma$

$F_R = F\cos\beta - mg\sin\alpha$

$ma = F\cos\beta - mg\sin\alpha$

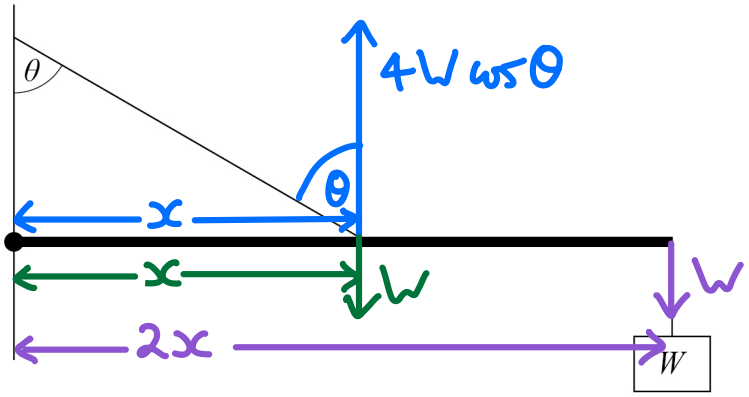
$a = \frac{F}{m}\cos\beta - g\sin\alpha$

Turn over for the next question

Do not write outside the box

1 9 The weight of a uniform bar is W.
An object also of weight W is attached to one end.
The bar is pivoted at the other end and held horizontal by a rope attached to its centre.
The tension in the rope is $4W$.

not to scale



What is angle θ?

[1 mark]

A 41° ✓

B 45°

C 60°

D 71°

$\curvearrowright M = \curvearrowleft M$

$W2x + Wx = 4Wx\cos\theta$

$2 + 1 = 4\cos\theta$

$\theta = \cos^{-1}(3/4) = 41.4°$

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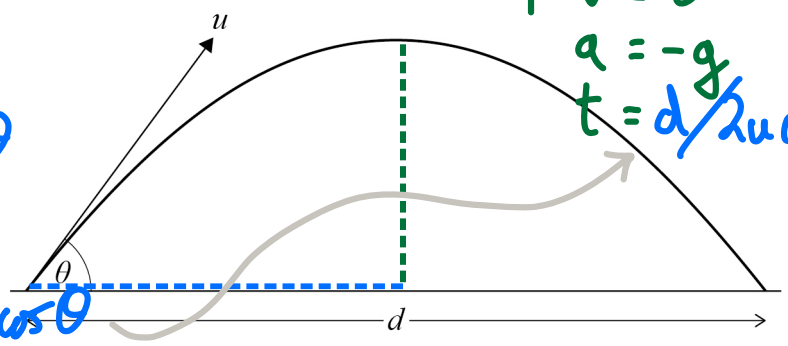
2 0 A projectile is fired from ground level over horizontal ground.

Its initial velocity is u at an angle θ to the horizontal.

The range of the projectile is d.



A second projectile is fired with a velocity $2u$ at the same angle.

What is the range of this projectile?
Assume that air resistance is negligible.

[1 mark]

A $\sqrt{2}d$ ⬭

B $2d$ ⬭

C $2\sqrt{2}d$ ⬭

D $4d$ ⬬ ✓

2 1 A particle travelling horizontally at 1.0×10^{7} m s^{-1} enters a region where it has a constant vertical acceleration of 4×10^{14} m s^{-2}.

What is the horizontal distance the particle has travelled in the region when its vertical displacement is 8×10^{-2} m?

[1 mark]

A 0.2 m ⬬ ✓

B 0.1 m ⬭

C 2×10^{-8} m ⬭

D 0.4×10^{-9} m ⬭

Do not write outside the box

Do not write outside the box

2 2 An object is thrown vertically upwards at time $t = 0$

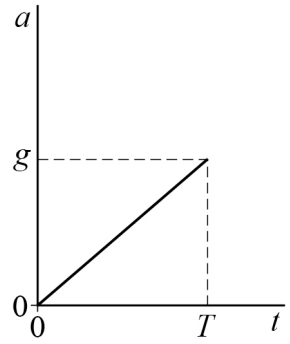
The object reaches its maximum height when $t = T$ and reaches its terminal speed on the way down.

The magnitude of the object's acceleration is a.

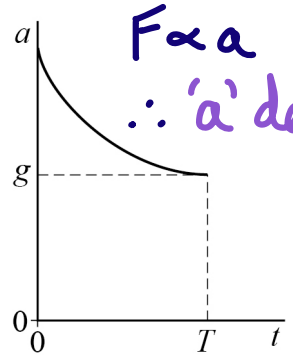
Which graph shows the variation of a with t?

[1 mark]

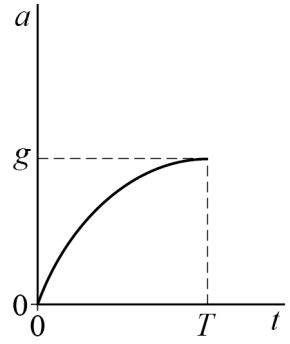
A



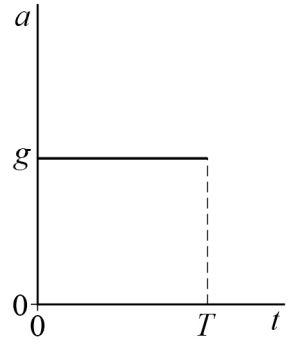
B



C



D



t=0 ↑v Weight Drag a

F∝a

∴ 'a' decreases in size

t=T v=0 Weight a

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2 3 A man has a mass of 75.0 kg.
He stands on weighing scales in a lift that accelerates upwards at 2.60 m s^{-2}.

What is the reading on the scales during the acceleration?

[1 mark]

A 195 N ⬭

B 541 N ⬭

C 736 N ⬭

D 931 N ⬬ ✓

$N - W = ma$

$N = W + ma = mg + ma$

$N = 75.0 \times (9.81 + 2.60)$

$N = 930.75$ N

2 4 An average force of 42 kN acts on the air passing through a jet engine. This force causes the speed of the air to increase by 540 m s^{-1}.

What mass of air passes through the engine in one minute?

[1 mark]

A 7.7×10^{-2} kg ⬭

B 4.7 kg ⬭

C 78 kg ⬭

D 4700 kg ⬬ ✓

$F = ma = m\frac{\Delta v}{\Delta t}$

$\frac{m}{\Delta t} = \frac{F}{\Delta v} = \frac{42\,000}{540} = 77.78$ kg s^{-1}

$77.78 \times 60 = 4667$ kg min^{-1}

2 5 A uniform wire is stretched by a load F.
The elastic strain energy stored in the wire is E.

The load is increased from F to $2F$.
The wire obeys Hooke's law.

What is the increase in the elastic strain energy stored in the wire?

[1 mark]

A E ⬭

B $2E$ ⬭

C $3E$ ⬬ ✓

D $4E$ ⬭

$E = \frac{1}{2}Fx = \frac{1}{2}kx^2$ $\quad F = kx$

$F \rightarrow 2F \quad x \rightarrow 2x \quad E \rightarrow 4E$

$\Delta E = 3E$

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2 6 A spring is compressed by a force F. The spring has stiffness k and its length changes by ΔL during the compression. When the force is removed the spring returns to its original length in time t.

What is the average power developed by the spring as it returns to its original length?

[1 mark]

A $\frac{k\Delta L}{2t}$ ⬭

B $\frac{k\Delta L}{t}$ ⬭

C $\frac{k(\Delta L)^2}{2t}$ ⬬ ✓

$P = \frac{E}{t} = \frac{\frac{1}{2}k(\Delta L)^2}{t} = \frac{k(\Delta L)^2}{2t}$

D $\frac{k(\Delta L)^2}{t}$ ⬭

2 7 A 12 Ω resistor is connected across the terminals of a battery of emf 2.0 V and internal resistance 4.0 Ω.

What is the pd across the resistor?

[1 mark]

A 0.25 V ⬭

B 0.75 V ⬭

C 1.30 V ⬭

D 1.50 V ⬬ ✓

$I = \frac{V}{R}$ $I = \frac{\varepsilon}{R+r}$

$\frac{V}{R} = \frac{\varepsilon}{R+r}$

$V = \varepsilon\frac{R}{R+r} = 2.0\frac{12}{12+4.0} = 2.0 \times \frac{3}{4} = 1.5\ V$

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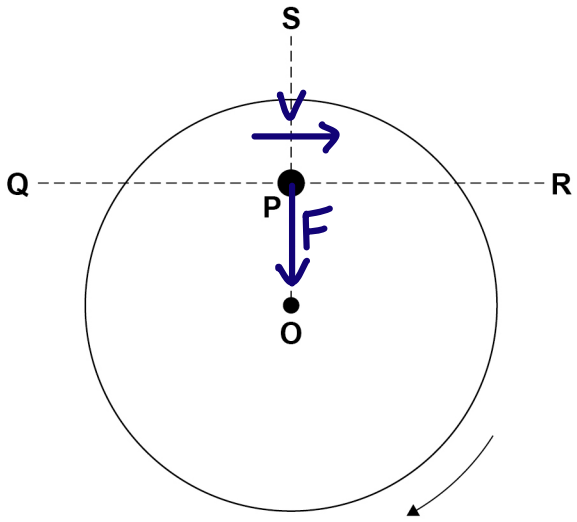
2 8 A small mass is placed at **P** on a horizontal turntable. The turntable rotates clockwise with a constant angular speed about a vertical axis through its centre **O**.

view of turntable from above



The mass remains at rest relative to the turntable.

What is the direction of the frictional force on the mass at the instant shown?

[1 mark]

A from **P** to **O** ✓

B from **P** to **Q**

C from **P** to **R**

D from **P** to **S**

Turn over for the next question

Do not write outside the box

2 9 A particle of mass m moves in a circle of radius r. The number of revolutions completed per second is f.

What is the kinetic energy of the particle?

[1 mark]

A $4\pi^2 mf^2 r^2$ ⬭

B $2\pi^2 mf^2 r^2$ ⬬ ✓

C $\frac{mf^2r^2}{4\pi^2}$ ⬭

D $\frac{mf^2r^2}{2}$ ⬭

$E_K = \frac{1}{2}mv^2$ $v = r\omega$ $\omega = 2\pi f$

$E_K = \frac{1}{2}mr^2\omega^2 = \frac{1}{2}mr^2 4\pi^2 f^2$

$E_K = 2mr^2\pi^2 f^2$

3 0 A body is in simple harmonic motion of amplitude 0.60 m and period 2π seconds.

What is its speed when its displacement is 0.20 m?

[1 mark]

A $0.32\ \text{m s}^{-1}$ ⬭

B $0.57\ \text{m s}^{-1}$ ⬬ ✓

C $0.63\ \text{m s}^{-1}$ ⬭

D $22\ \text{m s}^{-1}$ ⬭

$v = \omega\sqrt{A^2 - x^2}$

$\omega = \frac{2\pi}{T} = \frac{2\pi}{2\pi} = 1.0$

$v = 1.0 \times \sqrt{0.60^2 - 0.20^2}$

$v = 0.566\ \text{ms}^{-1}$

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3 1 When a mass **M** is suspended from a spring, the spring extends by a distance x.
M is displaced vertically and, when released, it oscillates with a period T.

M is removed and suspended from a different spring. The spring extends by a distance $\frac{x}{2}$.

M is again displaced vertically and released.

What is the new period of oscillations of **M**? **[1 mark]**

$F = kx \quad k \propto \frac{1}{x}$

$x_2 = \frac{x_1}{2} \quad \therefore \quad k_2 = 2k_1$

$T = 2\pi\sqrt{\frac{m}{k}}$

$T_1 \propto \sqrt{\frac{1}{k_1}} \quad T_2 \propto \sqrt{\frac{1}{2k_1}}$

A $\frac{T}{2}$ ⬭

B $\frac{T}{\sqrt{2}}$ ⬬ ✓

C $T\sqrt{2}$ ⬭

D $2T$ ⬭

3 2 A mass–spring system and a simple pendulum have identical periods of oscillation T when at the surface of the Earth.

Both are taken to planet **X** where the acceleration due to gravity is $\frac{g}{2}$.

What are the periods of the mass–spring system and the simple pendulum on **X**? **[1 mark]**

	Period of mass–spring system	Period of simple pendulum	
A	~~$\frac{T}{2}$~~	$T\sqrt{2}$	⬭
B	T	~~$2T$~~	⬭
C	T	$T\sqrt{2}$	⬬ ✓
D	~~$T\sqrt{2}$~~	~~T~~	⬭

25

$T = 2\pi\sqrt{\frac{m}{k}}$

END OF QUESTIONS

$T = 2\pi\sqrt{\frac{l}{g}}$

$\therefore$ No change

$T_E \propto \sqrt{\frac{1}{g_E}} \quad T_X \propto \sqrt{\frac{1}{g_E/2}} \propto \sqrt{\frac{2}{g_E}}$

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