Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

# A-level PHYSICS

## Paper 1

Specimen materials (set 2)

Time allowed: 2 hours

**Materials**

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

**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.
- 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 calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

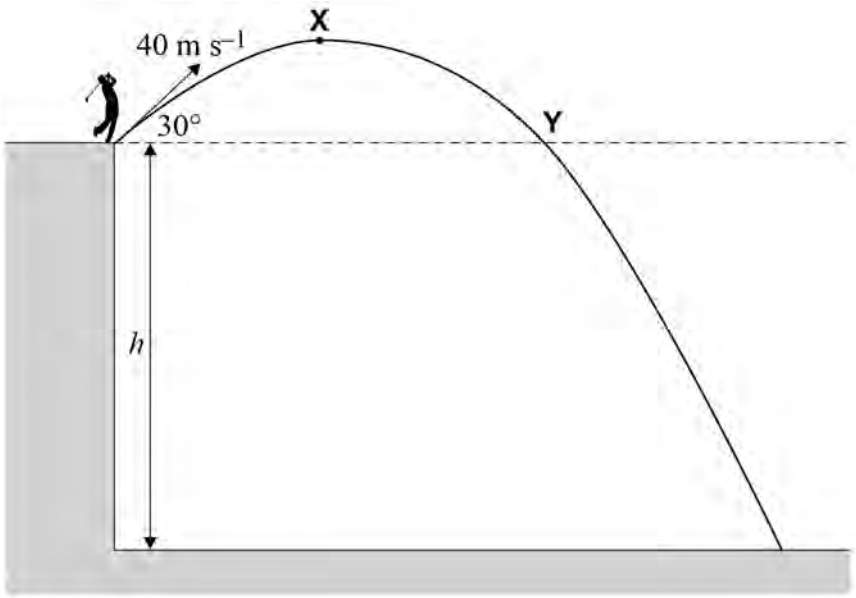
| For Examiner's Use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| MC | |
| **TOTAL** | |

## Section A

Answer **all** questions in this section.

**0 1** **Figure 1** shows a golfer hitting a ball from the top of a cliff. The ball follows the path shown. The ball is hit with an initial velocity of $40\ \text{m s}^{-1}$ at an angle of $30°$ above the horizontal, as shown. Assume that there is no air resistance.

**Figure 1**




**0 1 . 1** Calculate the initial vertical component of velocity of the ball.

**[1 mark]**

initial vertical component of velocity = _____ $\text{m s}^{-1}$

**0 1 . 2** Draw on the diagram an arrow to show the direction of the force acting on the ball when it is at point **X**, the highest point of the flight. Label this arrow **F**.

**[1 mark]**

**0 1 . 3** At point **Y** the ball is level with its initial position.

Show that the time taken to reach **Y** is about 4 s.

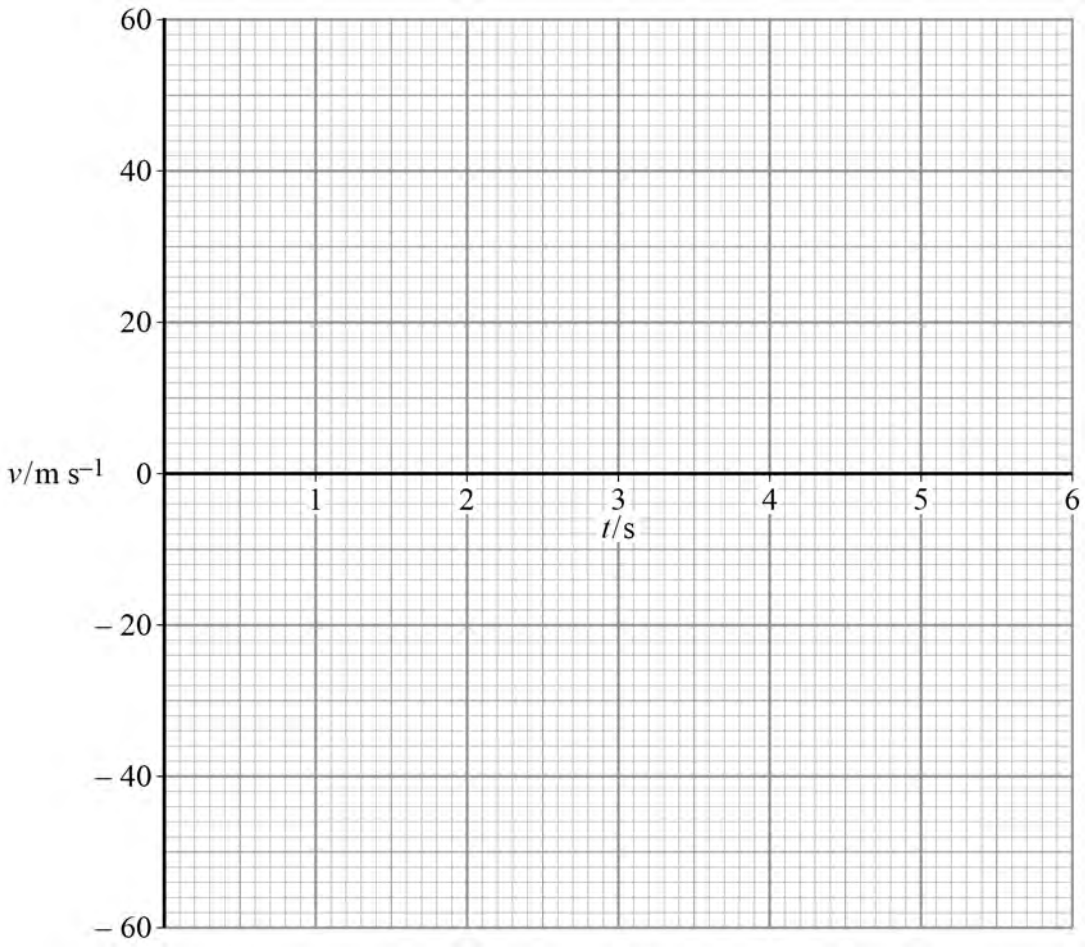
**[2 marks]**

**0 1 . 4** The total time of flight of the ball is 6.0 s.

Show on **Figure 2** how $v$, the vertical component of the velocity, changes throughout the whole 6.0 s.

**[3 marks]**

**Figure 2**




**Question 1 continues on the next page**

**0 1 . 5** Calculate the height $h$ of the cliff.

**[3 marks]**

height = _____ m

**0 1 . 6** In practice, the air resistance affects the path of the ball.

Draw on **Figure 1** the path the ball takes when air resistance is taken into account.

**[2 marks]**

**12**

**Turn over for the next question**

**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

**0 2 . 1** Distinguish between longitudinal and transverse waves.

**[2 marks]**

**0 2 . 2** A piano repairer replaces the wire that produces the highest note on a piano. The wire has a vibrating length of $0.050\ \text{m}$. He uses a wire with the following properties:

diameter = $3.5 \times 10^{-4}\ \text{m}$
density = $7.8 \times 10^{3}\ \text{kg m}^{-3}$
breaking stress = $3.0 \times 10^{9}\ \text{N m}^{-2}$

Calculate the tension required for the vibrating wire to produce its correct frequency of $4.1\ \text{kHz}$.

**[2 marks]**

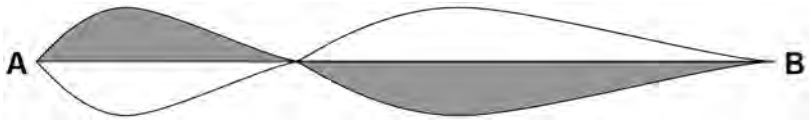
tension = _____ N

**0 2 . 3** Evaluate, using the data provided in **Question 2.2**, whether it is safe to use this wire.

**[2 marks]**

**0 2 . 4** The repairer uses faulty wire so that the diameter of the wire increases linearly with distance along its length. The profile of the vibration produced when the wire sounds its second harmonic is shown in **Figure 3**.

**Figure 3**




The speed $c$ of a transverse progressive wave travelling along a string of mass per unit length $\mu$ and under tension $T$ is given by

$$c = \sqrt{\frac{T}{\mu}}$$

Explain which end of the wire, **A** or **B**, has the greater diameter and why the profile of the stationary wave has the shape shown in **Figure 3**.

**[4 marks]**

**0 3** More than 200 subatomic particles have been discovered so far. However, most are not fundamental and are composed of other particles including quarks.

It has been shown that a proton can be made to change into a neutron and that protons and neutrons are made of quarks.

**0 3 . 1** Name **one** process in which a proton changes to a neutron.

**[1 mark]**

**0 3 . 2** Name the particle interaction involved in this process.

**[1 mark]**

**0 3 . 3** Write down an equation for the process you stated in **Question 3.1** and show that the baryon number and lepton number are conserved in this process.

**[2 marks]**

baryon number

lepton number

**0 3 . 4** The strange quark was used to explain the existence of particles whose tracks had been seen in experiments in the early 1950s. These were unexplained at that time and were referred to as 'strange particles'. One of these particles was later named the $K^+$ kaon.

State the quark composition of a $K^+$ kaon.

**[1 mark]**

**0 3 . 5** A $K^+$ kaon decays into a $\pi^+$ particle and a $\pi^o$ particle.

Explain **one** property which is conserved and **one** property which is not conserved in this decay.

**[2 marks]**

conserved

not conserved

7

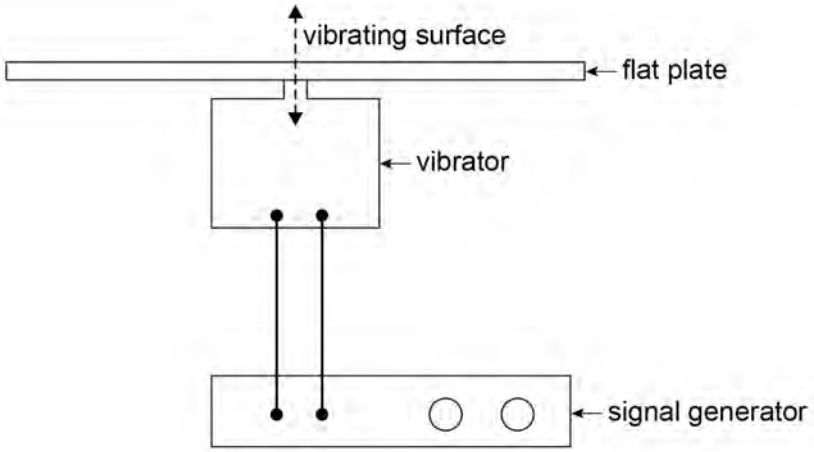
**Turn over for the next question**

**0 4 . 1** State the conditions for simple harmonic motion.

**[2 marks]**

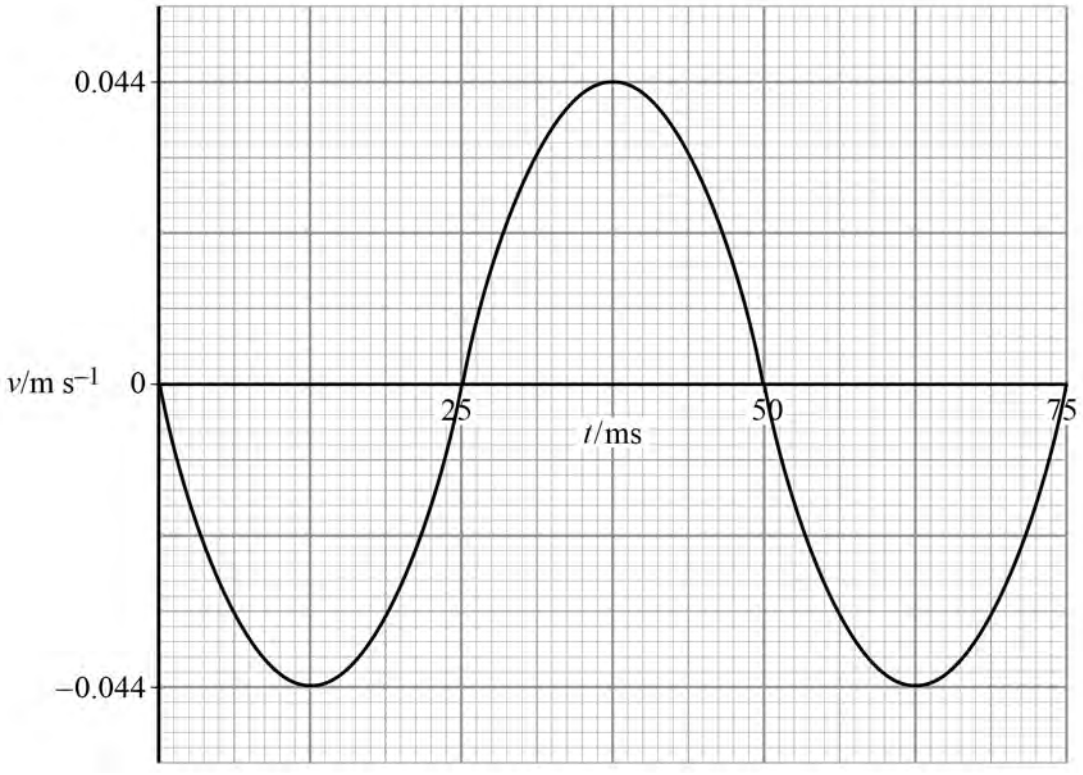
**0 4 . 2** A rigid flat plate is made to vibrate vertically with simple harmonic motion. The frequency of the vibration is controlled by a signal generator as shown in **Figure 4.**

**Figure 4**




The velocity–time ($v$–$t$) graph for the vibrating plate at one frequency is shown in **Figure 5**.

**Figure 5**




Show that the maximum displacement of the plate is $3.5 \times 10^{-4}$ m.

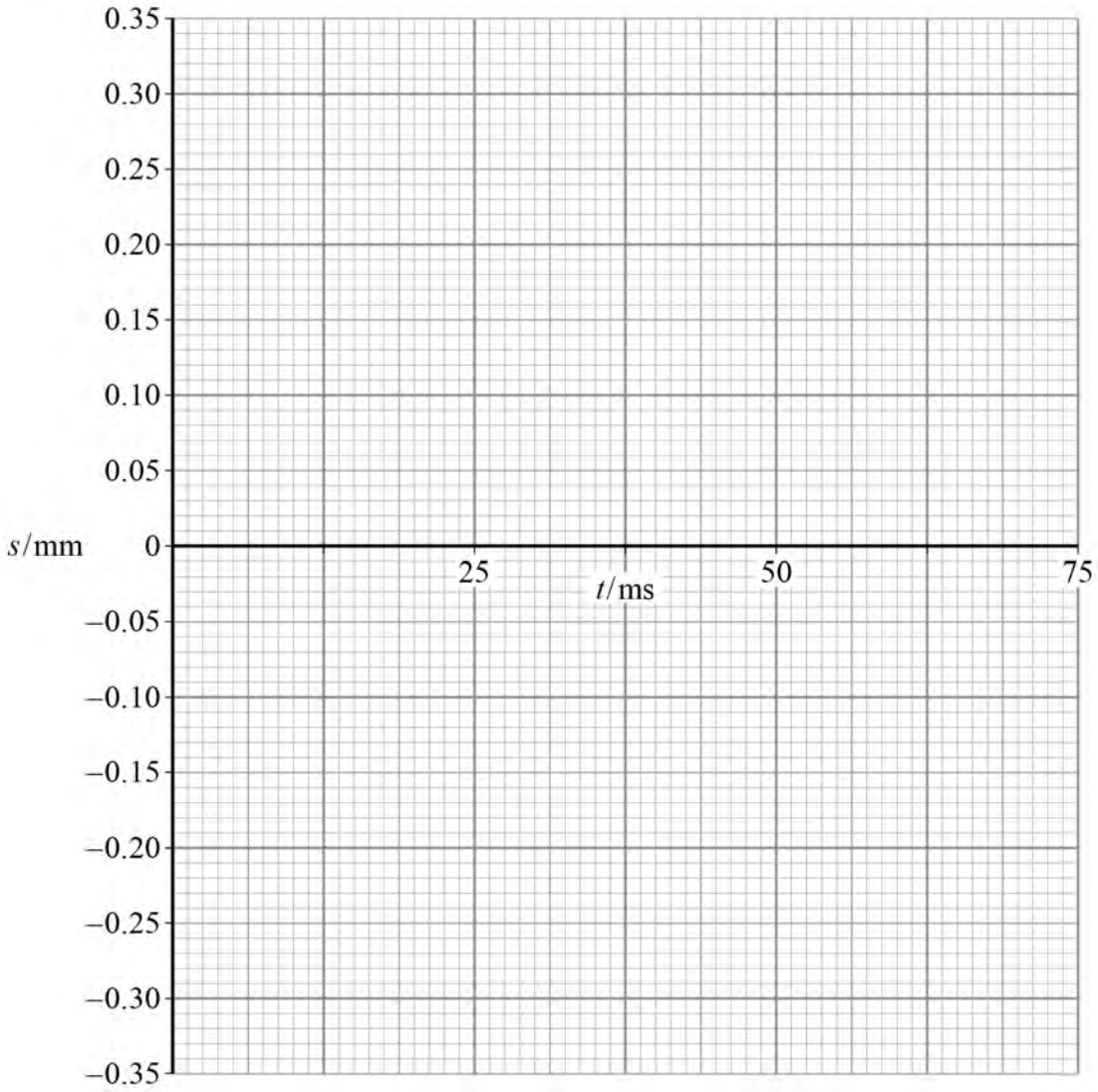
**[2 marks]**

**Question 4 continues on the next page**

**0 4 . 3** Draw on **Figure 6** the displacement–time ($s$–$t$) graph between 0 and 75 ms.

**[1 mark]**

**Figure 6**




**0 4 . 4** State **one** time at which the plate has maximum potential energy.

**[1 mark]**

time = _____ s

**0 4 . 5** A small quantity of fine sand is placed onto the surface of the plate. Initially the sand grains stay in contact with the plate as it vibrates. The amplitude of the vibrating surface remains constant at $3.5 \times 10^{-4}$ m over the full frequency range of the signal generator. Above a particular frequency the sand grains lose contact with the surface.

Explain how and why this happens.

**[3 marks]**

**0 4 . 6** Calculate the lowest frequency at which the sand grains lose contact with the surface of the plate.

**[2 marks]**

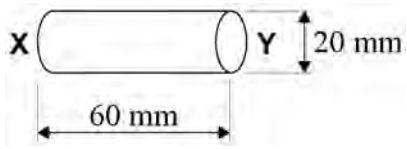
frequency = _____ Hz

11

**Turn over for the next question**

**0 5** **Figure 7** shows a cylinder of conducting putty which is $60\ \text{mm}$ long and $20\ \text{mm}$ in diameter.

**Figure 7**




**0 5 . 1** The conducting putty obeys Ohm's law.

State Ohm's law.

**[1 mark]**

_____

_____

_____

_____

**0 5 . 2** A $1.50\ \text{V}$ dc supply of negligible internal resistance is connected across the ends **X** and **Y** of the cylinder of putty. The resistance of the cylinder of putty is $20.0\ \Omega$.

Calculate, in $\text{mA}$, the current in the putty.

**[1 mark]**

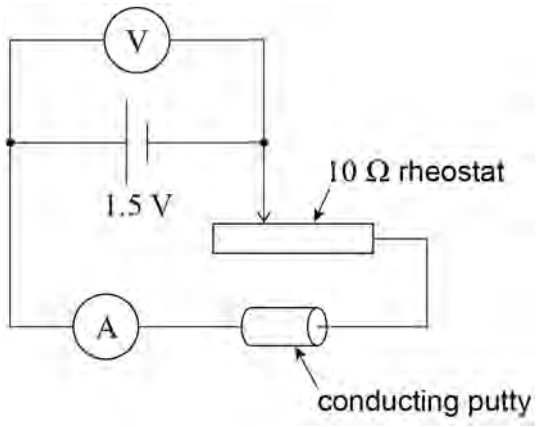
current = _____ $\text{mA}$

**0 5 . 3** A student suggests an arrangement for demonstrating that the putty obeys Ohm's law.

Discuss any problems that make the circuit and components shown in **Figure 8** unsuitable for this purpose.

**[4 marks]**

**Figure 8**




**Question 5 continues on the next page**

**0 5 . 4** Show that the resistivity $\rho$ of the putty can be calculated using the formula

$$\rho = \frac{R}{l^2} \times volume\ of\ the\ cylinder$$

where $R$ is the resistance of the cylinder and $l$ is the length of the cylinder.

**[1 mark]**

**0 5 . 5** Calculate, using the formula in **Question 5.4**, the resistivity of the putty.
Give an appropriate unit for your answer.

**[3 marks]**

resistivity = _____ unit = _____

**10**

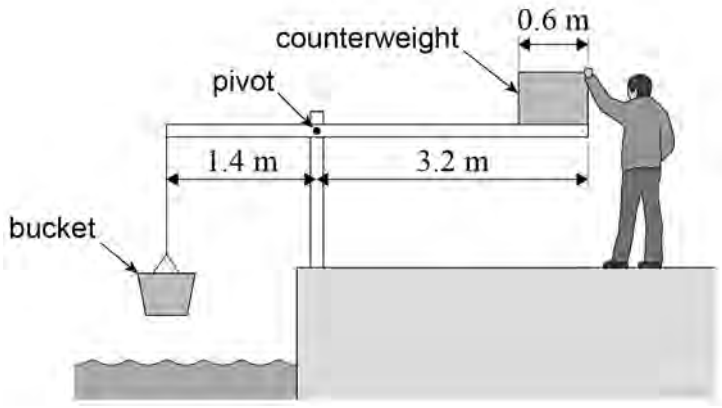
**Turn over for the next question**

**DO NOT WRITE ON THIS PAGE**
**ANSWER IN THE SPACES PROVIDED**

**0 6** A shaduf is a device used to lift water from a well. It consists of an upright support to which a uniform beam is pivoted. It can be assumed that the weight of the beam is negligible. On one end of the beam is a counterweight, and on the other a bucket which can hold the water.

**Figure 9** shows a diagram of a typical shaduf.

**Figure 9**




The counterweight is of uniform material and has a weight of $50\ \text{N}$. It is $0.60\ \text{m}$ long.

**0 6 . 1** Calculate the moment of the counterweight about the pivot when the beam is horizontal.

**[2 marks]**

moment = _____ N m

**0 6 . 2** The bucket has a weight of $120\ \text{N}$ and has a capacity of $0.16\ \text{m}^3$. When the bucket is half full, a force is required at the end of the beam to lift the bucket and water.

Calculate the value of this force when the beam is horizontal.

density of water = $1000\ \text{kg m}^{-3}$

**[5 marks]**

additional force = _____ N

**0 6 . 3** Explain how the force in **Question 6.2** would be different if the weight of the beam is **not** considered to be negligible.

**[3 marks]**

**END OF SECTION A**

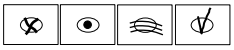
10

## Section B

Each of Questions **7** to **31** 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 answer 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.

**0 7** Which nucleus has a smaller value of specific charge than the nucleus $^{18}_{8}\mathrm{O}$ ?

**[1 mark]**

**A** $^{7}_{3}\mathrm{Li}$ ⬭

**B** $^{11}_{5}\mathrm{B}$ ⬭

**C** $^{13}_{6}\mathrm{C}$ ⬭

**D** $^{37}_{17}\mathrm{Cl}$ ⬭

**0 8** When bombarded with an $\alpha$ particle the nuclide $^{25}_{12}\mathrm{Mg}$ changes into another nuclide with the emission of a neutron and $\gamma$ radiation.

What are the correct values for the nucleon number and proton number of the nuclide which is formed?

**[1 mark]**

| | Nucleon number | Proton number | |
|---|---|---|---|
| **A** | 29 | 14 | ⬭ |
| **B** | 29 | 12 | ⬭ |
| **C** | 28 | 14 | ⬭ |
| **D** | 27 | 12 | ⬭ |

**0 9** Which sequence of radioactive emissions results in the formation of an isotope of the original element?

**[1 mark]**

**A** one $\alpha$ particle and one $\beta^-$ particle ⬭

**B** one $\alpha$ particle and two $\beta^-$ particles ⬭

**C** two $\alpha$ particles and one $\beta^-$ particle ⬭

**D** two $\alpha$ particles and two $\beta^-$ particles ⬭

**1 0** Which statement concerning the forces between particles is **incorrect**?

**[1 mark]**

**A** Leptons experience the weak interaction. ⬭

**B** Leptons experience the strong interaction. ⬭

**C** Hadrons experience the weak interaction. ⬭

**D** Hadrons experience the strong interaction. ⬭

**1 1** What of the following is a hadron of zero charge?

**[1 mark]**

**A** neutrino ⬭

**B** photon ⬭

**C** proton ⬭

**D** neutron ⬭

**Turn over for the next question**

**1 2** What is the correct order of increasing photon energy in the electromagnetic spectrum?
1 is least energy, 4 is greatest energy.

**[1 mark]**

| | **Radio waves** | **γ rays** | **Visible light** | **Infrared** | |
|---|---|---|---|---|---|
| **A** | 1 | 4 | 3 | 2 | ⬭ |
| **B** | 4 | 1 | 2 | 3 | ⬭ |
| **C** | 1 | 4 | 2 | 3 | ⬭ |
| **D** | 4 | 1 | 3 | 2 | ⬭ |

**1 3** Electromagnetic radiation incident on a metal surface can cause electrons to be emitted.

Which of the following statements is correct?

**[1 mark]**

**A** Every photon incident on the surface causes an electron to be emitted. ⬭

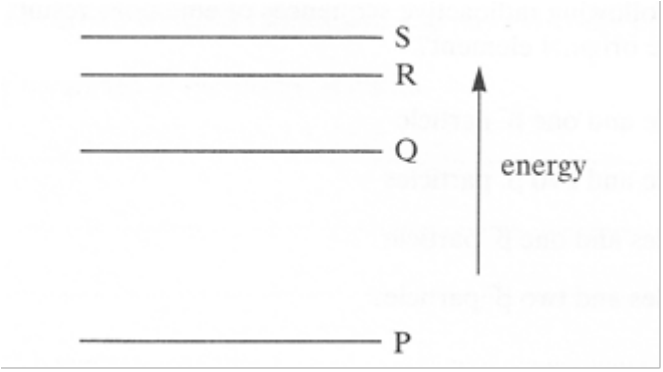
**B** All the emitted electrons have the same energy. ⬭

**C** The range of energy of the emitted electrons depends on the intensity of the radiation. ⬭

**D** If the incident radiation is of a single frequency, the number of electrons emitted per second increases if the intensity of the radiation increases. ⬭

**1 4** The diagram shows the four lowest energy levels for an electron in an atom. P, Q, R and S represent, to scale, the relative energy values of these energy levels.

**[1 mark]**



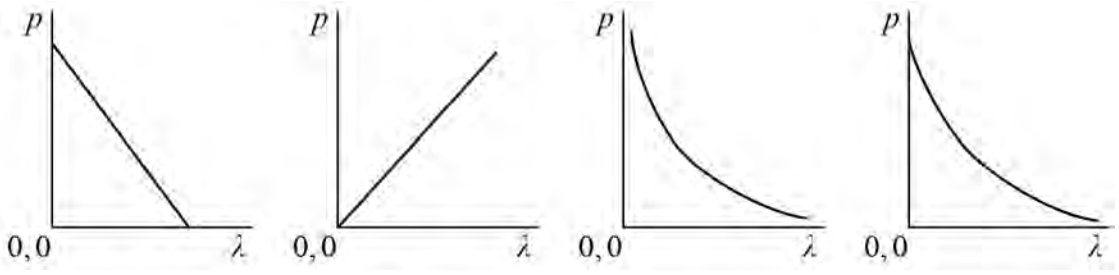

An electron transition from level R to level Q is accompanied by the emission of a photon of visible light.

Which electron transition would be accompanied by the emission of a photon of infrared radiation?

**A** S to R ○
**B** S to Q ○
**C** Q to P ○
**D** R to P ○

**1 5** Which graph best shows the relationship between the momentum $p$ and the wavelength $\lambda$ for photons?

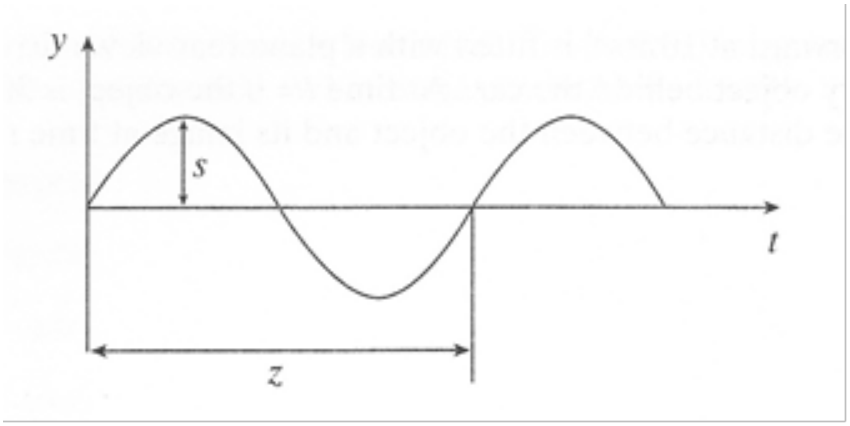
**[1 mark]**




**A** **B** **C** **D**

**A** ○
**B** ○
**C** ○
**D** ○

**1 6** For waves on a water surface, the following graph shows how the displacement $y$ of a water particle in the surface varies with the time $t$.




What are the quantities $z$ and $s$?

**[1 mark]**

| | $z$ | $s$ | |
|---|---|---|---|
| **A** | frequency | amplitude | ⬭ |
| **B** | period | half-amplitude | ⬭ |
| **C** | wavelength | half-amplitude | ⬭ |
| **D** | period | amplitude | ⬭ |

**1 7** Two coherent sources generate sound waves of wavelength $0.40\ \text{m}$. The waves leave the sources in phase. A detector some distance from the sources receives the sound waves. The path difference between the detector and the sources is $0.90\ \text{m}$.

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

**[1 mark]**

**A** zero ⬭

**B** 45° ⬭

**C** 90° ⬭

**D** 180° ⬭

**1 8** Monochromatic light of wavelength $600\ \text{nm}$ is used to illuminate a pair of slits $0.50\ \text{mm}$ apart. The fringes are observed at a distance of $1.50\ \text{m}$ from the slits.

What is the separation of the fringes?

**[1 mark]**

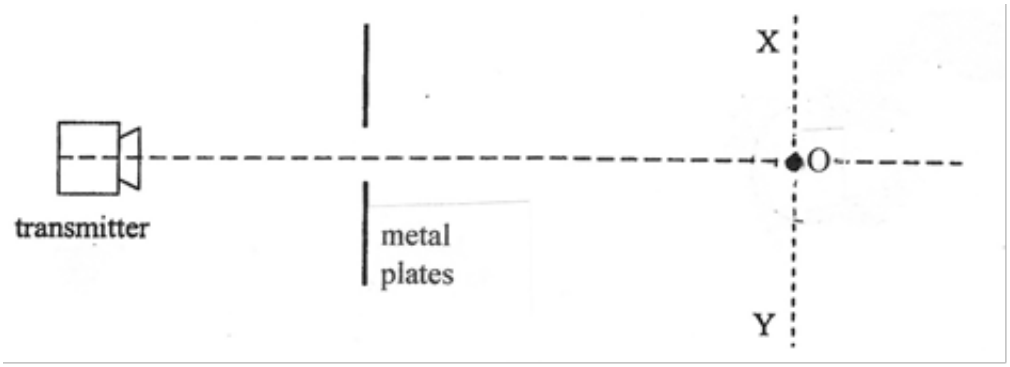
**A** $2.0 \times 10^{-7}\ \text{mm}$ ⬭

**B** $1.8 \times 10^{-3}\ \text{mm}$ ⬭

**C** $5.6 \times 10^{-1}\ \text{mm}$ ⬭

**D** $1.8\ \text{mm}$ ⬭

**1 9** Microwaves from a transmitter are incident on a gap between two metal plates. The microwaves that pass through the gap are detected by a receiver.




The receiver is placed at O.

What change causes the received signal to decrease and then increase?

**[1 mark]**

**A** make the gap narrower ⬭

**B** move the receiver towards X ⬭

**C** rotate the receiver through $90°$ ⬭

**D** move the transmitter away from the receiver ⬭

**2 0** What is correct for the quantities impulse and force?

**[1 mark]**

| | **Impulse** | **Force** | |
|---|---|---|---|
| **A** | scalar | scalar | ⬭ |
| **B** | scalar | vector | ⬭ |
| **C** | vector | scalar | ⬭ |
| **D** | vector | vector | ⬭ |

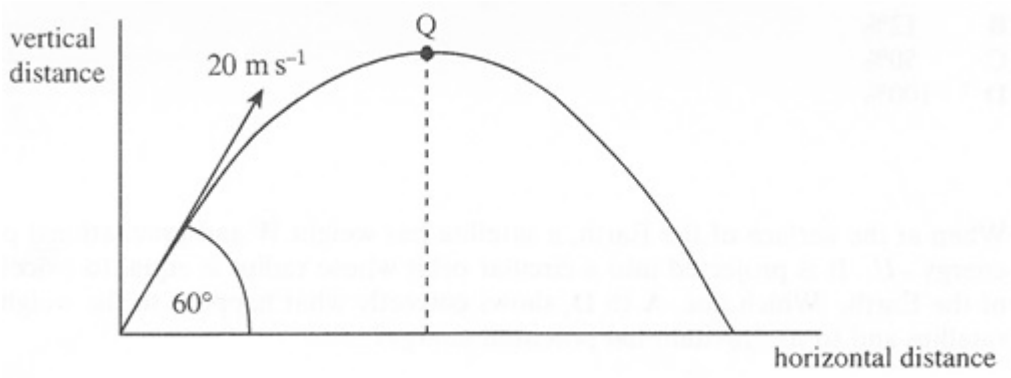
**2 1** A firework is fired vertically up into the air and subsequently falls to the ground.

Which quantity relating to the motion of the rocket is never zero before it hits the ground? Assume that air resistance is negligible.

**[1 mark]**

**A** acceleration ⬭
**B** velocity ⬭
**C** momentum ⬭
**D** kinetic energy ⬭

**2 2** A ball of mass $0.20\ \text{kg}$ is thrown and moves in a curved path, as shown below. At Q it is travelling horizontally.




Assume air resistance is negligible.

What is the momentum of the ball at Q?

**[1 mark]**

**A** zero ⬭
**B** $2.0\ \text{N s}$ ⬭
**C** $3.5\ \text{N s}$ ⬭
**D** $4.0\ \text{N s}$ ⬭

**2 3** A steel wire has a cross-sectional area $0.5\ \text{mm}^2$. The Young modulus of steel is $2.0 \times 10^{11}\ \text{Pa}$. Assume the wire obeys Hooke's law.

What load must be suspended from the wire to produce an extension which is $0.1\%$ of the original length?

**[1 mark]**

**A** 40 N ⬭

**B** 50 N ⬭

**C** 100 N ⬭

**D** 200 N ⬭

**2 4** When a constant potential difference (pd) is applied across the ends of a uniform wire there is a current $I$ in the wire.

The wire is replaced by one made from the same material, but of double the length and double the diameter. The same pd is applied across the ends.

What is the new current?

**[1 mark]**

**A** $4I$ ⬭

**B** $2I$ ⬭

**C** $\frac{I}{2}$ ⬭

**D** $\frac{I}{4}$ ⬭

**2 5** A pd $V$ is applied across a resistor. Another identical resistor is then connected in series with it and the same pd $V$ is applied across the combination.

Which statement is **incorrect**?

**[1 mark]**

**A** The total resistance is doubled. ⬭

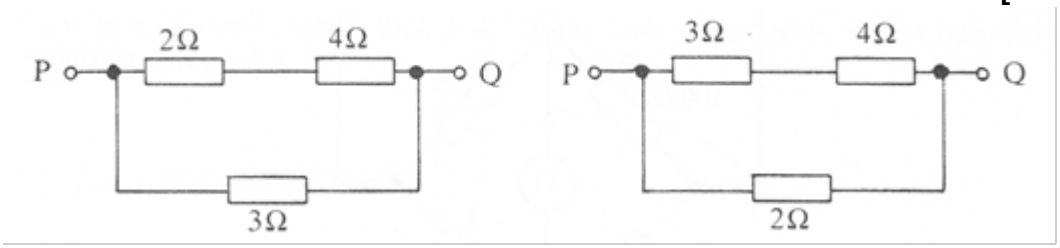
**B** The pd across one resistor is $\frac{V}{2}$. ⬭

**C** The current in the resistors is halved. ⬭

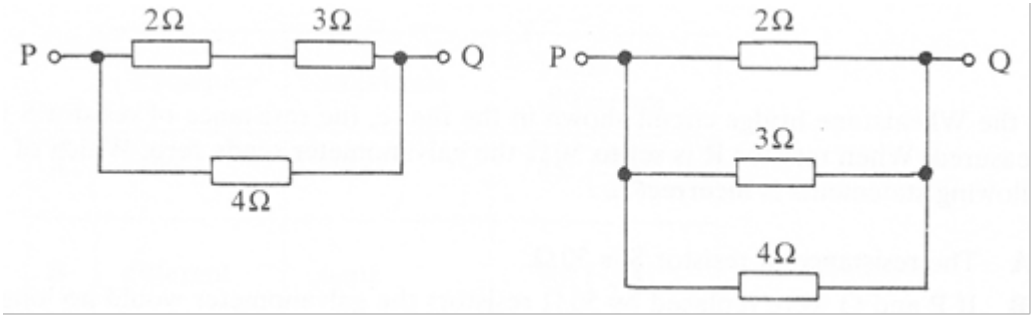
**D** The power dissipated in one resistor is halved. ⬭

**2 6** Which resistor arrangement has the greatest value of resistance?

**[1 mark]**



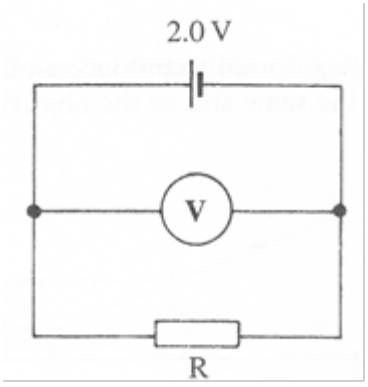

**A** **B**




**C** **D**

**A** ⬭
**B** ⬭
**C** ⬭
**D** ⬭

**2 7** The cell in the following circuit has an emf of $2.0\ \text{V}$ and an internal resistance of $1.0\ \Omega$.




The digital voltmeter reads $1.6\ \text{V}$. What is the resistance of R?

**[1 mark]**

**A** $0.4\ \Omega$ ⬭
**B** $1.0\ \Omega$ ⬭
**C** $2.0\ \Omega$ ⬭
**D** $4.0\ \Omega$ ⬭

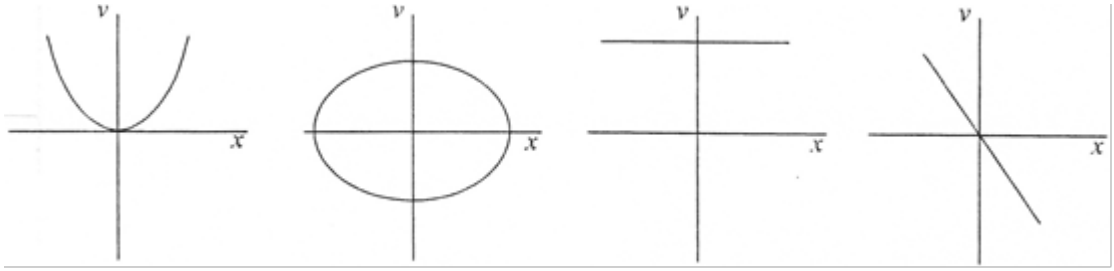
**2 8** A helicopter circles continuously at a constant speed around a horizontal path of diameter 800 m, taking 5.0 minutes to complete each orbit of the path.

What are the speed $v$ and the centripetal acceleration $a$ of the helicopter?

**[1 mark]**

| | $v$ / m s$^{-1}$ | $a$ / m s$^{-2}$ | |
|---|---|---|---|
| **A** | 0.021 | 0.18 | ⬭ |
| **B** | 8.4 | 0.088 | ⬭ |
| **C** | 8.4 | 0.18 | ⬭ |
| **D** | 17 | 0.35 | ⬭ |

**2 9** Which graph shows how the velocity $v$ of a body moving with simple harmonic motion varies with its displacement $x$?




**A** **B** **C** **D**

**[1 mark]**

**A** ⬭
**B** ⬭
**C** ⬭
**D** ⬭

**Turn over for the next question**

**3 0** A simple pendulum and a mass–spring system perform simple harmonic oscillations on Earth with the same period $T$. Both systems are moved to a region where the gravitational field strength is four times that at the surface of Earth.

What is the period of each system when oscillating at this new location?

**[1 mark]**

| | Pendulum | Mass–spring | |
|---|---|---|---|
| **A** | $\frac{T}{2}$ | $T$ | ⬭ |
| **B** | $\frac{T}{4}$ | $T$ | ⬭ |
| **C** | $4T$ | $2T$ | ⬭ |
| **D** | $2T$ | $2T$ | ⬭ |

**3 1** A mechanical oscillator is set into motion by a periodic driving force whose frequency is steadily increased from a low value.

What is correct for this system?

**[1 mark]**

**A** Forced vibrations occur only at particular frequencies. ⬭

**B** The oscillator is subject to damping only at the resonant frequency. ⬭

**C** When resonance occurs the damping force is a minimum. ⬭

**D** The oscillator will not continue to resonate when the periodic driving force is removed. ⬭

**END OF QUESTIONS**

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