Please write clearly in block capitals.

Centre number

Candidate number

Surname

Forename(s)

Candidate signature

AS
PHYSICS

Paper 1

Specimen materials (set 2)

Time allowed: 1 hour 30 minutes

Materials
For this paper you must have:
- a pencil
- a ruler
- a 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 70.
- You are expected to use a calculator where appropriate.

Answer **all** questions.

0 1 Cosmic rays are high-energy particles coming from Space. They collide with the air molecules in the Earth's atmosphere to produce pions and kaons.

0 1 . 1 Pions and kaons are mesons. Identify the quark–antiquark composition for a meson.

Tick (✓) the correct answer in the right-hand column.

[1 mark]

	✓ if correct
qqq	
$q\bar{q}\bar{q}$	
$q\bar{q}$	
qq	

0 1 . 2 A positron with a kinetic energy of 2.0 keV collides with an electron at rest, creating two photons that have equal energy.

Show that the energy of each photon is 8.2×10^{-14} J.

[3 marks]

0 1 . 3 Calculate the wavelength of a photon of energy 8.2×10^{-14} J.

[2 marks]

wavelength = ______________________ m

0 1 . 4 Show that the speed of the positron before the collision was about 2.7×10^7 m s^{-1}.

[3 marks]

0 1 . 5 Calculate the de Broglie wavelength of the positron travelling at a speed of 2.7×10^7 m s^{-1}.

[2 marks]

wavelength = ________________________ m

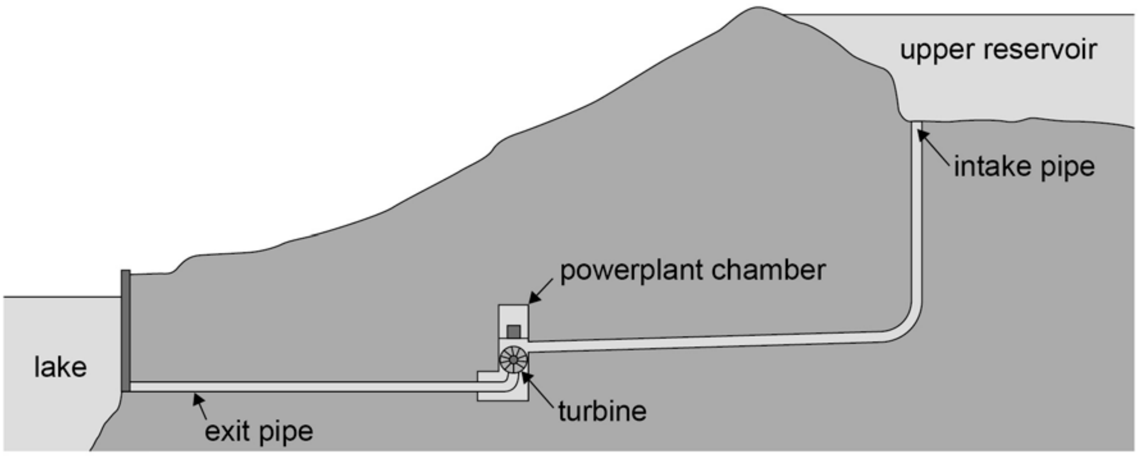
0 1 . 6 The separation between the carbon atoms in graphite is about 0.15 nm.

Discuss whether the electrons in **Question 1.5** can be used to demonstrate diffraction as they pass through a sample of graphite.

[4 marks]

0 2 **Figure 1** shows a possible design for a pumped storage system used to generate electricity.

Figure 1



Water from the upper reservoir is to fall through a vertical distance of $90\ \mathrm{m}$ before reaching a powerplant chamber. The water rotates a turbine in the chamber that drives an electricity generator. After leaving the turbine, the water travels through an exit pipe to a lake.

0 2 . 1 Show that the maximum possible speed of the water as it arrives at the turbine is about $40\ \mathrm{m\ s^{-1}}$.

[2 marks]

0 2 . 2 The volume of water flowing into the turbine every second is $3.5\ \mathrm{m^3}$.

Estimate the radius of the intake pipe that is required for the system.

[2 marks]

pipe radius = ____________________ m

0 2 . 3 The water leaves the powerplant chamber at a speed of 12 m s^{-1}.

Calculate the maximum possible power output of the turbine and generator.
Give an appropriate unit for your answer.

[4 marks]

maximum power output = ____________________ unit =____________

0 2 . 4 Energy losses are estimated to reduce the output power for the turbine and generator to 60% of the value you calculated in **Question 2.3**.

Explain **two** possible reasons for this energy loss.

[2 marks]

1 ____

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2 ____

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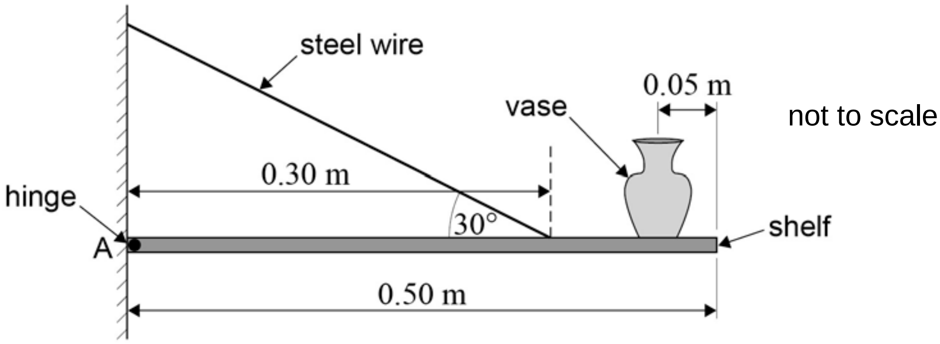
0 3 **Figure 2** shows a vase placed on a uniform shelf that is supported by a steel wire.

Figure 2



The mass of the vase is $0.65\ \mathrm{kg}$ and the mass of the shelf is $2.0\ \mathrm{kg}$. The shelf is hinged at A. The steel wire is attached to the shelf $0.30\ \mathrm{m}$ from A and is at an angle of $30°$ to the shelf. The other end of the steel wire is attached to the wall.

0 3 . 1 State the principle of moments.

[2 marks]

0 3 . 2 Show, by taking moments about A, that the tension in the steel wire is about $50\ \mathrm{N}$.

[4 marks]

0 3 . 3 The cross-sectional area of the steel wire is 7.8×10^{-7} m^2. The steel has a Young modulus of 180 GPa.

Calculate the tensile strain of the steel wire when it is holding up the shelf and the vase.

[2 marks]

tensile strain = ____________________

Turn over for the next question

0 4

A car is designed to break the land speed record. The thrust exerted on the car is 230 kN at one instant of its motion. The mass of the car at this instant is 11 000 kg.

0 4 . 1 The acceleration of the car at this instant is 2.9 m s^{-2}.

Calculate the air resistance acting on the car.

[3 marks]

air resistance = ____________________ N

0 4 . 2 The thrust on the car remains constant as the speed increases.

Explain why the acceleration decreases and eventually reaches zero.

[2 marks]

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0 4 . 3 A supersonic car is attempting to break the land speed record on a horizontal track. When it is travelling at 320 m s^{-1}, a small part **P** that is 1.5 m above the ground becomes detached from the car. The initial vertical velocity of **P** is 2.5 m s^{-1} in the upwards direction.

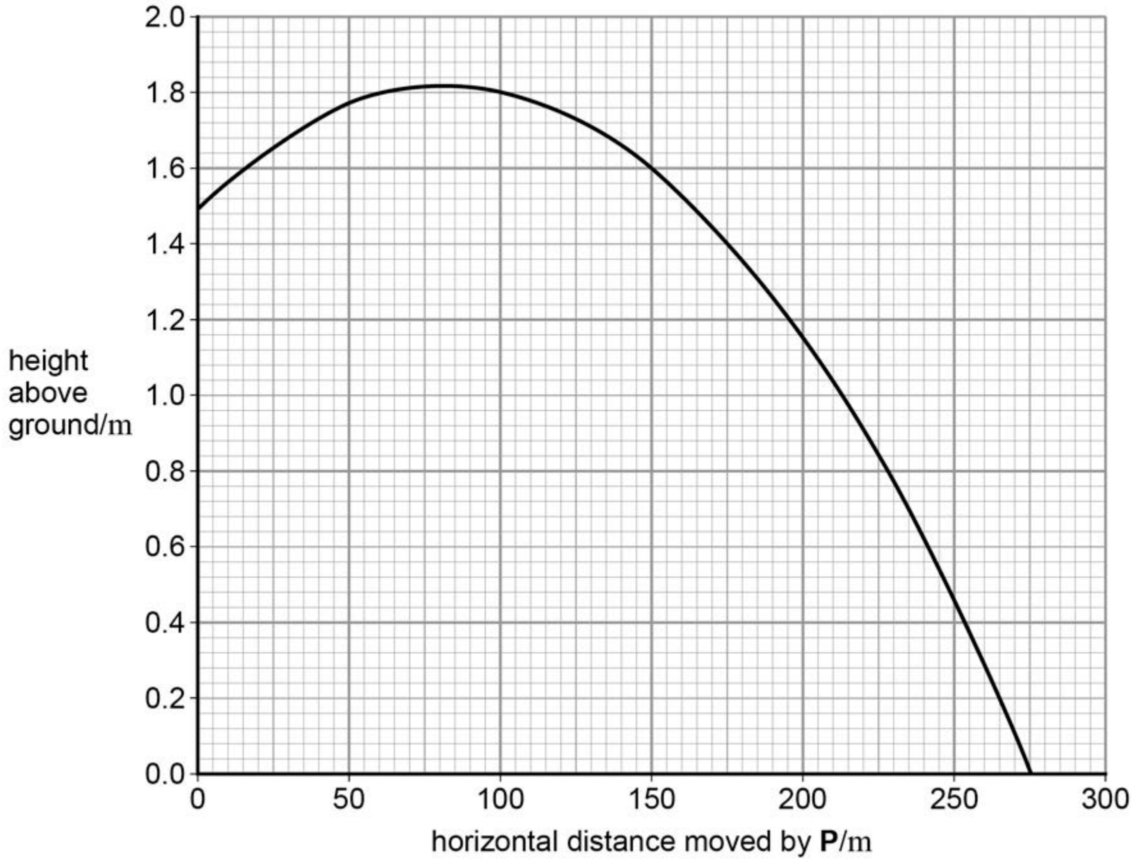
Calculate the time taken for the small part **P** to reach the ground.
Assume that air resistance has a negligible effect on the vertical motion.

[3 marks]

time = ____________________ s

0 4 . 4 **Figure 3** shows the path that **P** would follow from the instant that it became detached if there were no air resistance in the horizontal direction**.**

Figure 3



In practice, air resistance is not negligible in the horizontal direction.

Draw, on **Figure 3**, a line to show the path that **P** would follow assuming that air resistance only affects motion in the horizontal direction.

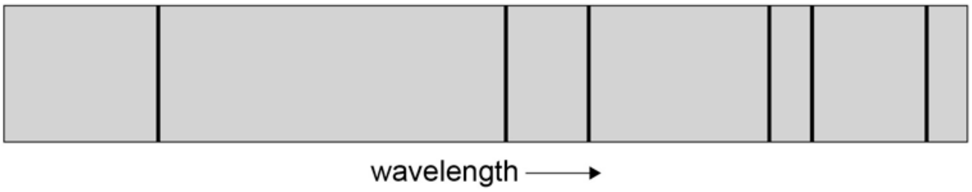
[2 marks]

0 4 . 5 Explain your answer to **Question 4.4**, including the reason why air resistance is negligible in the vertical direction.

[2 marks]

0 5 **Figure 4** shows the line spectrum of a gas.

Figure 4



0 5 . 1 Explain how line spectra are produced. In your answer you should describe:

- how the collisions of charged particles with gas atoms can cause the atoms to emit photons
- how spectral lines are explained by the concept of discrete energy levels.

[6 marks]

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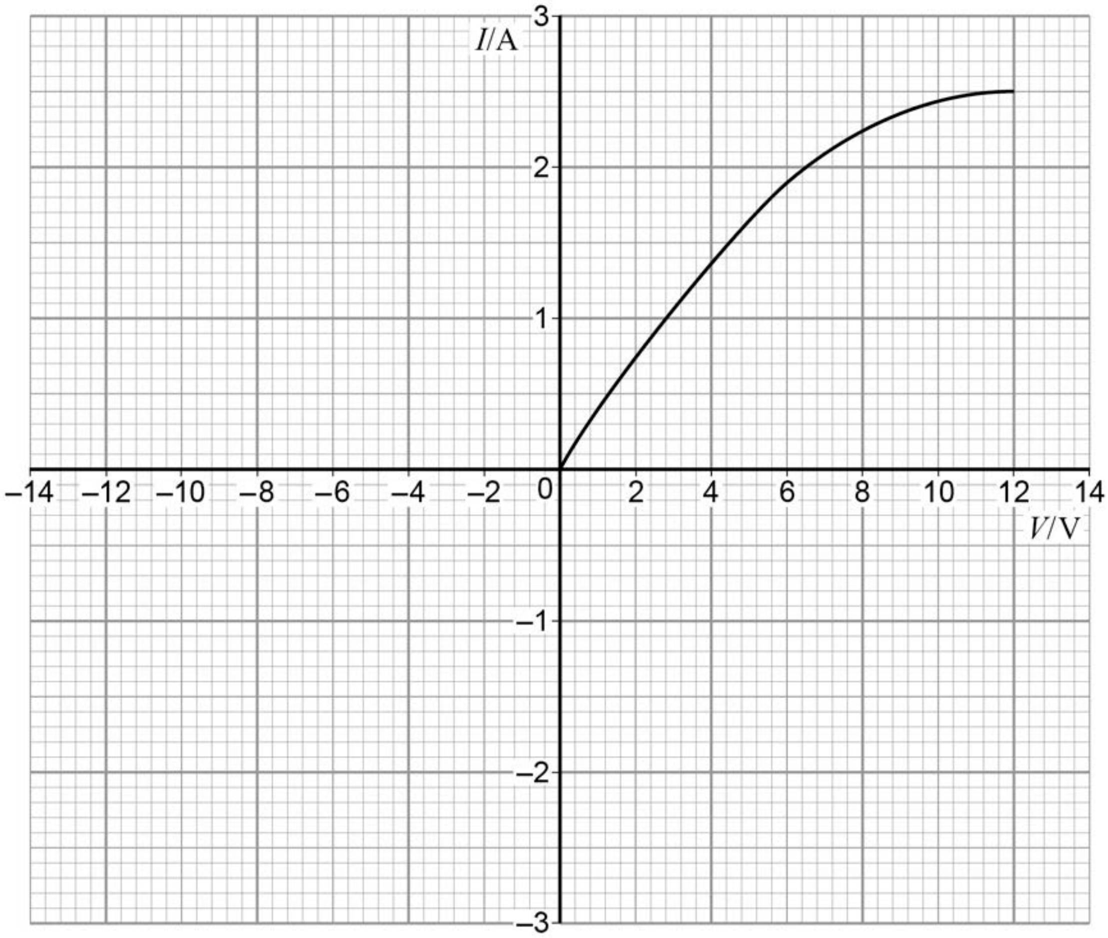
Turn over for the next question

0 6 **Figure 5** shows the current–voltage (I–V) characteristic of the lamp used in a car headlight up to its working voltage.

Figure 5



0 6 . 1 Draw on **Figure 5** the characteristic that would be obtained with the connections to the supply reversed.

[2 marks]

0 6 . 2 Lamps are marked with their working voltage and the power used at this voltage. For example, a lamp for use in a torch may be marked 2.5 V 0.3 W.

Deduce the marking on the lamp for the car headlight.

[2 marks]

lamp marking = __________ V __________ W

0 6 . 3 Determine the resistance of the lamp when the potential difference (pd) across it is half the working voltage.

[1 mark]

resistance = ____________________ Ω

0 6 . 4 Explain, without further calculation, how the resistance of the lamp varies as the voltage across it is increased from zero to its working voltage.

[3 marks]

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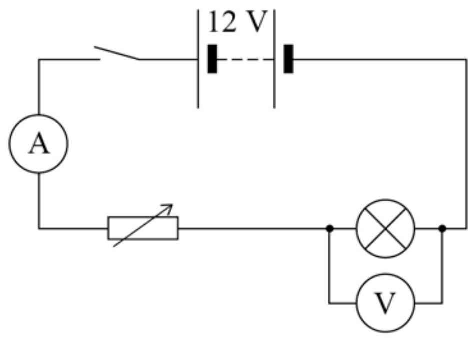
Question 6 continues on the next page

0 6 . 5 A student suggests that the circuit shown in **Figure 6** is suitable for collecting data to draw the I–V characteristic of the lamp up to its working voltage.
The maximum resistance of the variable resistor is $6.0\ \Omega$ and the internal resistance of the power supply is $2.0\ \Omega$.
The resistance of the ammeter is negligible.

Figure 6



Discuss the limitations of this circuit when used to collect the data for the characteristic.

[2 marks]

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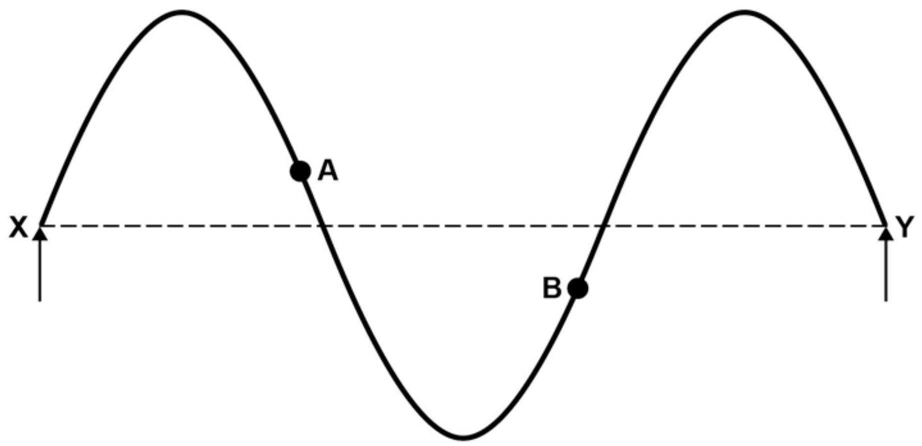
0 7 **Figure 7** shows one position of a guitar string stretched between points **X** and **Y**. The string vibrates at a frequency of 330 Hz.

Figure 7



0 7 . 1 State the phase relationship between points **A** and **B** on the string.

[1 mark]

____

0 7 . 2 Points **X** and **Y** are 0.66 m apart.

Calculate the speed of the wave along the string.

[2 marks]

speed = ____________________ $m\ s^{-1}$

Question 7 continues on the next page

0 7 . 3 The total mass of the string is $3.1\ \mathrm{g}$ and the total length of the string is $0.91\ \mathrm{m}$.

Show that the tension in the string when it is sounding the harmonic shown in **Figure 7** is about $70\ \mathrm{N}$.

[3 marks]

0 7 . 4 The string is fixed at one end and wrapped around a tuning peg of radius $3.0\ \mathrm{mm}$ at the other. The tuning peg needs to be turned through 3 complete rotations to increase the tension in the string from 0 to $70\ \mathrm{N}$ in **Question 7.3**.

Discuss, by estimating the energy stored in the string, whether there is a significant risk to the guitar player when the string breaks.

[3 marks]

END OF QUESTIONS