

## A Level Physics A H556/03 Unified physics

### Practice paper – Set 1 Time allowed: 1 hour 30 minutes



**You must have:**

- the Data, Formulae and Relationship booklet

**You may use:**

- a scientific calculator
- a ruler (cm/mm)

<b>First name</b>											
<b>Last name</b>											
<b>Centre number</b>							<b>Candidate number</b>				

#### INSTRUCTIONS

- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

#### INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets [ ].
- Quality of extended responses will be assessed in questions marked with an asterisk (\*).
- This document consists of **16** pages.

Answer **all** the questions

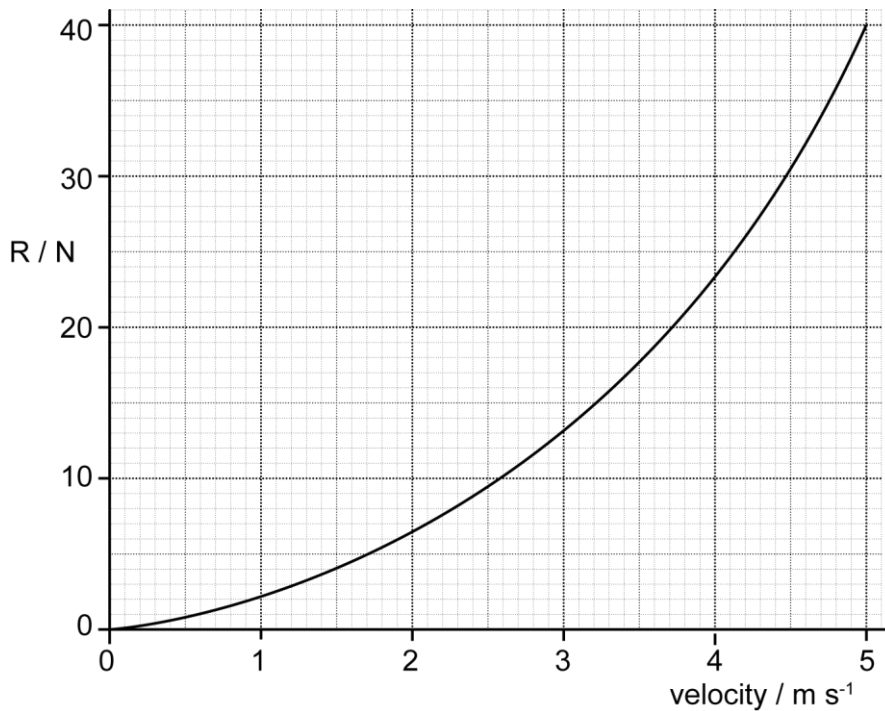
- 1 (a) The kilogram, metre and second are SI base units.

Determine the unit for *power* in terms of these SI units.

unit for power = ..... [1]

- (b) When riding at a steady speed on the flat, a cyclist provides a constant power of 200 W to the rear wheel of his bicycle. The total mass of bicycle and rider is 120 kg.

The total resistive forces *R* acting against the motion of the bicycle and the rider vary with the velocity *v* of the bicycle as shown in Fig. 1.



**Fig.1**

- (i) The cyclist starts from rest. He pedals steadily along a horizontal road. This exerts a constant forward force of 40 N on the bicycle.

Use Fig. 1 to state and explain how the acceleration and velocity of the bicycle vary as the cyclist travels along the road.

.....

.....

.....

.....

.....

.....

.....

.....

..... [3]

(ii) Calculate

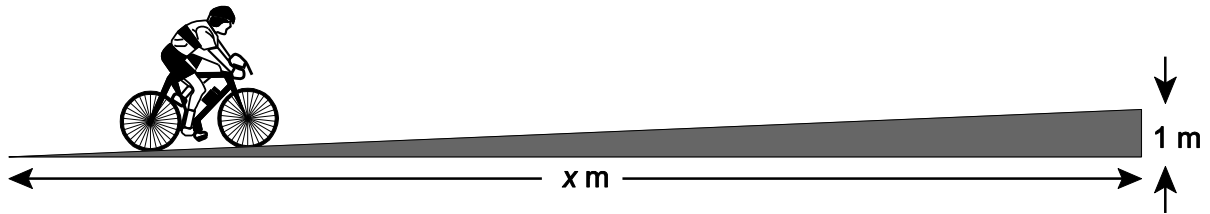
1 the initial acceleration of the bicycle

acceleration = .....  $\text{m s}^{-2}$  [1]

2 the maximum speed of the cyclist.

maximum speed = .....  $\text{m s}^{-1}$  [2]

(c) The cyclist reaches a hill.



The cyclist has to double the power provided to the rear wheel to maintain the same maximum speed reached on the flat road.

Assume that the total resistive force is unchanged.

The gradient of the hill is 1 in  $x$ .

Calculate  $x$ .

$x =$  .....  $\text{m}$  [3]

- 2 Electrons in a beam are accelerated from rest by a potential difference  $V$  between two vertical plates before entering a uniform electric field of electric field strength  $E$  between two horizontal parallel plates, a distance  $2d$  apart.

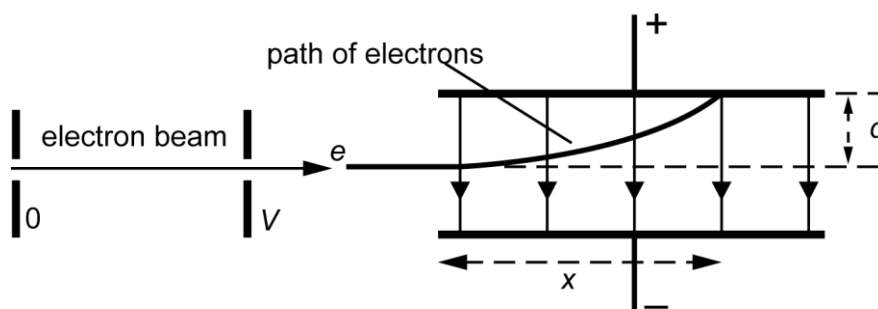


Fig. 2.1

The path of the electrons is shown in Fig. 2.1. The electron beam travels a horizontal distance  $x$  parallel to the plates before hitting the top plate. The beam has been deflected through a vertical distance  $d$ .

- (a) Show that  $x$  is related to  $V$  by the equation

$$x^2 = \frac{4dV}{E}$$

[5]

- (b) For different values of the accelerating p.d.  $V$ , the horizontal distance  $x$  is recorded. A table of results is shown with a third column giving values of  $x^2$  including the absolute uncertainties.

$V / \text{V}$	$x / \text{cm}$	$x^2 / \text{cm}^2$
500	$3.3 \pm 0.1$	$10.9 \pm 0.7$
600	$3.6 \pm 0.1$	$13.0 \pm 0.7$
700	$3.9 \pm 0.1$	$15.2 \pm 0.8$
800	$4.2 \pm 0.1$	$17.6 \pm 0.8$
900	$4.5 \pm 0.1$	$20.3 \pm 0.9$
1000	$4.7 \pm 0.1$	

- (i) Complete the missing value in the table, including the absolute uncertainty.

[1]

- (ii) Fig. 2.2 shows the axes for a graph of  $x^2$  on the  $y$ -axis against  $V$  on the  $x$ -axis. The first four points have been plotted including error bars for  $x^2$ . Use data from the table to complete the graph. [2]

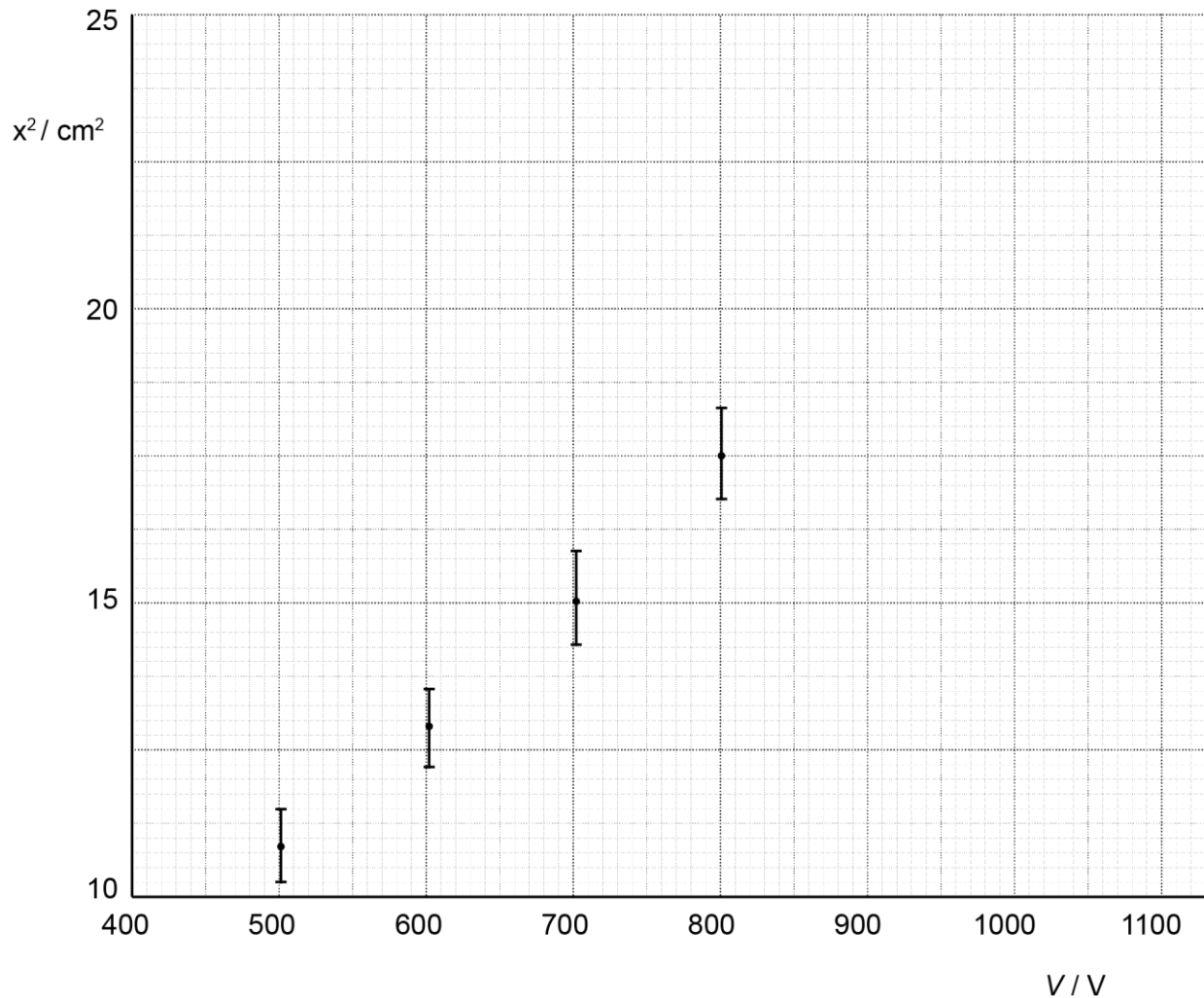


Fig. 2.2

- (iii) The separation of the horizontal plates is  $4.0 \pm 0.1$  cm. Use the graph to determine a value for  $E$ . Include the absolute uncertainty and an appropriate unit in your answer

$E = \dots\dots\dots \pm \dots\dots\dots \text{unit} \dots\dots\dots$  [4]

- 3 (a) The equation of state of an ideal gas is  $pV = nRT$ . Explain why the temperature must be measured in kelvin.

.....  
 .....  
 .....  
 ..... [2]

- (b) A meteorological balloon rises through the atmosphere until it expands to a volume of  $1.0 \times 10^6 \text{ m}^3$ , where the pressure is  $1.0 \times 10^3 \text{ Pa}$ . The temperature also falls from  $17^\circ\text{C}$  to  $-43^\circ\text{C}$ .

The pressure of the atmosphere at the Earth's surface =  $1.0 \times 10^5 \text{ Pa}$ .

Show that the volume of the balloon at take off is about  $1.3 \times 10^4 \text{ m}^3$ .

[3]

- (c) The balloon is filled with helium gas of molar mass  $4.0 \times 10^{-3} \text{ kg mol}^{-1}$  at  $17^\circ\text{C}$  at a pressure of  $1.0 \times 10^5 \text{ Pa}$ .

Calculate

- (i) the number of moles of gas in the balloon

number of moles = ..... [2]

- (ii) the mass of gas in the balloon.

mass = .....kg [1]

- (d) The internal energy of the helium gas is equal to the random kinetic energy of all of its molecules.

When the balloon is filled at ground level at a temperature of  $17^{\circ}\text{C}$ , the internal energy is 1900 MJ.

Estimate the internal energy of the helium when the balloon has risen to a height where the temperature is  $-43^{\circ}\text{C}$ .

internal energy = .....MJ [1]

- (e) The acceleration of the balloon and its instruments at the Earth's surface as it is released is  $27 \text{ m s}^{-2}$ .

The density of the air at the Earth's surface is  $1.3 \text{ kg m}^{-3}$ .

Calculate the total mass  $M$  of the helium-filled balloon and its load.

$M = \text{.....kg}$  [3]

4 (a) Explain what is meant by the statement:

*The gravitational potential at the Earth's surface is  $-62.7 \times 10^6 \text{ J kg}^{-1}$ .*

.....  
.....  
.....  
.....  
..... [3]

(b) The International Space Station (ISS) circles the Earth at a height of  $4.0 \times 10^5 \text{ m}$ .

Its mass is  $4.2 \times 10^5 \text{ kg}$ .

The radius of the Earth is  $6.4 \times 10^6 \text{ m}$ .

(i) Show that the speed of the ISS in orbit is about  $8 \text{ km s}^{-1}$ .

[3]

(ii) Calculate the total energy of the ISS.

total energy = ..... J [2]





- 5 Fig. 5.1 shows a horizontal copper wire placed between the opposite poles of a permanent magnet. The wire is held in tension  $T$  by the clamps at each end. The length of the wire in the magnetic field of flux density  $0.032$  tesla is  $6.0$  cm.

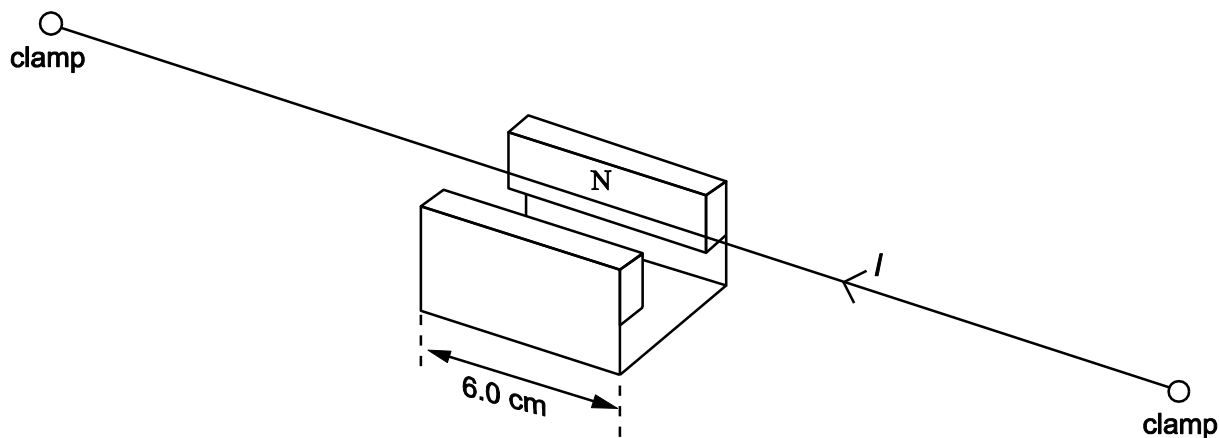


Fig. 5.1

- (a) A direct current  $I$  of  $2.5$  A is passed through the wire as shown.

(i) On Fig. 5.1 draw an arrow to indicate the direction of the force  $F$  on the wire. [1]

(ii) Calculate the magnitude of  $F$ .

$$F = \dots\dots\dots \text{N} \quad [1]$$

- (b) The direct current is changed to an alternating current of constant amplitude and variable frequency, causing the wire to oscillate. The frequency of the current is increased until the fundamental natural frequency of the wire is found as shown in Fig. 5.2. This is  $70$  Hz.

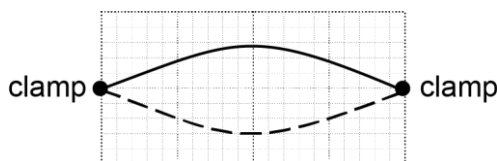


Fig. 5.2

- (i) In the situation shown in Fig. 5.2 the amplitude of the oscillation of the centre point of the wire is  $4.0$  mm. Calculate the maximum acceleration of the wire at this point.

$$\text{maximum acceleration} = \dots\dots\dots \text{m s}^{-2} \quad [2]$$

- (ii) The frequency is increased until another stationary wave pattern occurs. The amplitude of this stationary wave is much smaller.

1 Sketch this pattern on Fig. 5.3 and state the frequency

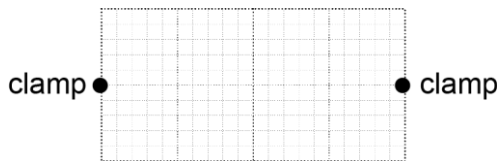


Fig. 5.3

frequency = ..... Hz [1]

2 Explain why the amplitude is so small. Suggest how the experiment can be modified to increase the amplitude.

.....  
 .....  
 .....  
 .....  
 ..... [3]

(c) The speed  $v$  of a transverse wave along the wire is given by  $v = \sqrt{\frac{T}{\mu}}$  where  $T$  is the tension and  $\mu$  is the mass per unit length of the wire.

(i) Assume that both the length and mass per unit length remain constant when the tension in the wire is halved. Calculate the frequency of the new fundamental mode of vibration of the wire.

frequency = .....Hz [1]

(ii) In practice the mass per unit length changes because the wire contracts when the tension is reduced. For the situation in which the tension is halved the strain reduction is found to be 0.4%.

1 Calculate the percentage change in  $\mu$ . State both the size and sign of the change.

percentage change in  $\mu$  = .....% [1]

2 Write down the percentage error this causes in your answer to (c)(i). State, giving your reasoning, whether the actual frequency would be higher or lower than your value.

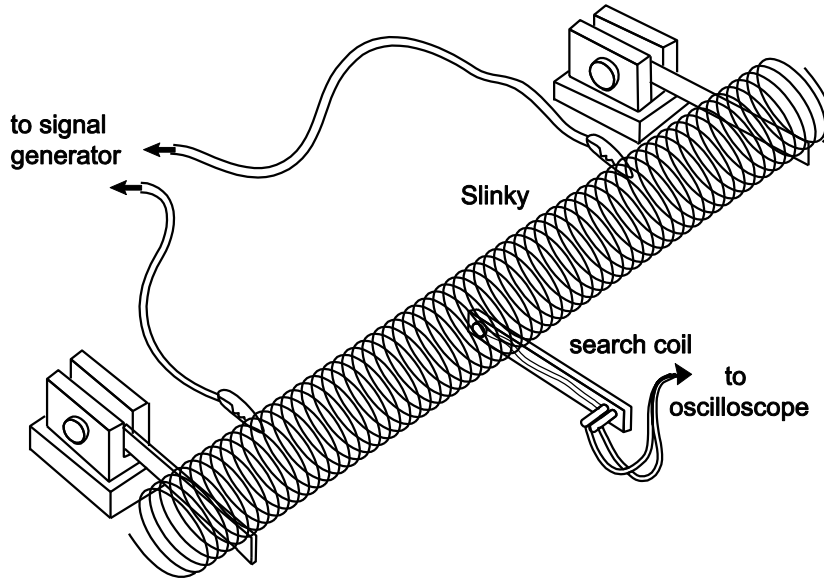
.....  
 .....  
 ..... [2]

6 (a)\* A student is to investigate the magnetic field inside and around a solenoid.

It is suggested that the magnetic field strength  $B$  inside a long solenoid is determined by various quantities, namely  $B \propto \frac{NI}{L}$

where  $N$  is the number of turns,  $L$  is the length of the solenoid and  $I$  is the current in the wire.

Apparatus is set up for an experiment as shown in Figure 6.1.



**Fig. 6.1**

A Slinky is a long spring about 70 mm in diameter which can be stretched easily and uniformly. The search coil has 5000 turns and the signal generator can produce a constant alternating current at a frequency between 0 and 1 kHz.

Plan an experiment using this equipment to investigate the validity of the relationship between  $B$ , at the centre of the solenoid, and **one** of the variables  $N$  or  $L$ . Explain how you will make your measurements, how sensitive they will be and the steps that you will take to make this a valid test.

.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....  
.....

- (b) Fig. 6.2 shows a soft iron ring of variable circular cross-section. It has four coils containing 2, 3, 4 and 5 turns wound around it. The cross-sectional area of the ring is different for each coil.

A cell is connected across the coil with three turns.

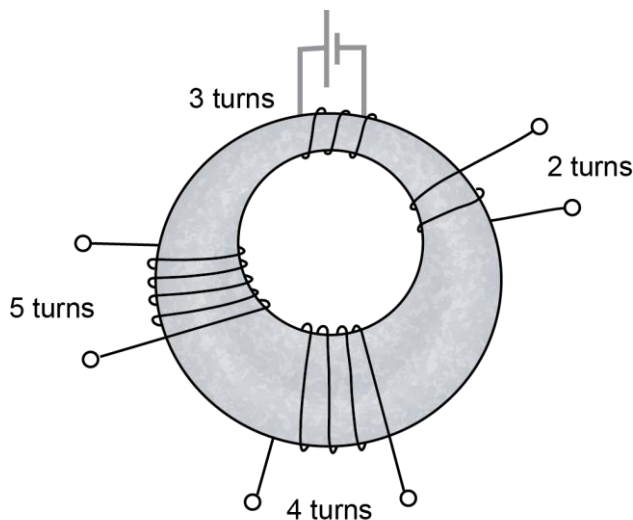


Fig. 6.2

- (i) Draw on Fig. 6.2 the complete paths of **two** lines of magnetic flux produced by the three-turn coil when there is a current in it. [1]

- (ii) State which **one** of the following three quantities,

*magnetic flux*      *magnetic flux density*      *magnetic flux linkage*

is most nearly the same for all four coils in Fig. 6.2. Give a reason for your answer.

.....  
 ..... [1]

- (iii) Write down **one** of the **other** two quantities in (ii) above. State in which coil this quantity has the largest value. Give a reason for your answer.

.....  
 ..... [2]

**END OF QUESTION PAPER**

**ADDITIONAL ANSWER SPACE**

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).

A large area of the page is filled with horizontal dashed lines, intended for providing additional answer space. A solid vertical line is positioned on the left side of this area, defining a margin for writing the question number(s).



