Specimen Papers and Mark Schemes for Physics

For first AS Examination in 2009
For first A2 Examination in 2010

Subject Code: 1210

physics

Contents

Subject Code	1210
QAN	500/2471/1
QAN	500/2438/3

Specimen Papers

Centre number

71	

Candidate number

Rewarding Learning

ADVANCED
General Certificate of Education
2009

Physics

Assessment Unit AS 1

Forces, Energy and Electricity

SPECIMEN PAPER

TIME

1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in question 7.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
Total Marks	

1 **(a)** **(i)** State the difference between a **vector** quantity and a **scalar** quantity.

____

____

____ [1]

(ii) Which of the following list of quantities are **scalars**?

energy displacement distance speed mass acceleration velocity

Scalars:

____

____ [2]

(b) Two forces of magnitude 16 N and 12 N act on an object of mass 5.0 kg at the same time.

(i) Calculate the minimum and maximum acceleration that the object can experience when the two forces act on it.
You are advised to show your working clearly.

Minimum acceleration = ___________ $m\ s^{-2}$

Maximum acceleration = ___________ $m\ s^{-2}$ [4]

(ii) Calculate the magnitude of the resultant force and the angle it makes with the 16 N force when the two forces act at 90° to each other.
You are advised to show your working clearly.

Magnitude of resultant force = ___________ N

Angle with 16 N force = ___________ ° [3]

2 The speed-time graph shown in **Fig. 2.1** represents the motion of three cyclists A, B and C as they move along a straight, horizontal road.

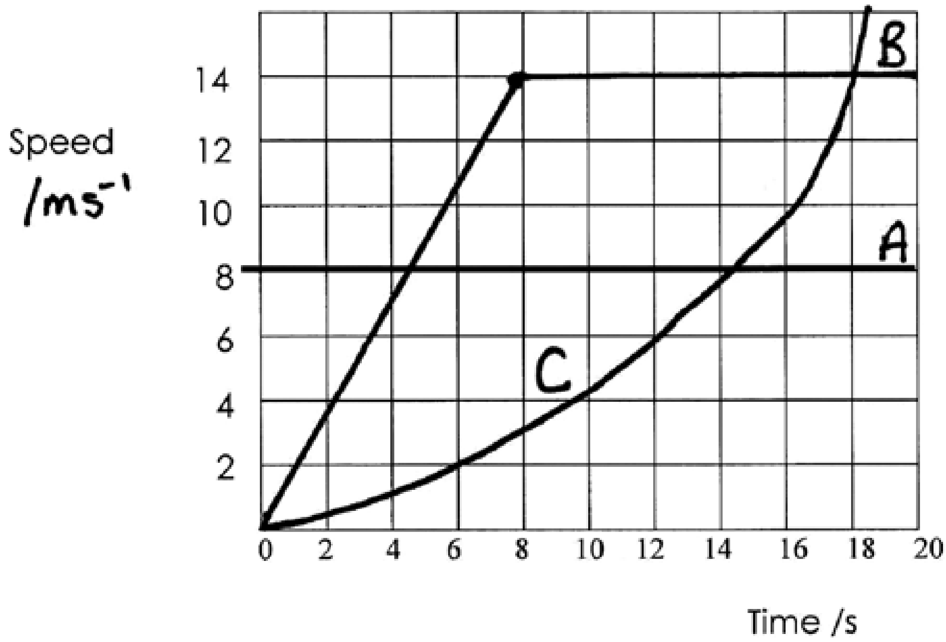


Fig. 2.1

(a) Describe the motion of each of the cyclists shown on the graph between 0 and 20 seconds.

Cyclist A: ____

____ [1]

Cyclist B: ____

____ [2]

Cyclist C: ____

____ [1]

(b) (i) Calculate the distance travelled by cyclist B during the first 12 s of the motion.
You are advised to show your working clearly.

Distance travelled by B = ______________ m [3]

(ii) Describe how the acceleration of cyclist C at a time of 10 s could be found from the graph.

____

____

____ [2]

(c) At time t = 0, cyclist A and cyclist B are level.

(i) At what time is cyclist A at his maximum distance ahead of cyclist B?

Time = ________________ s [1]

(ii) Explain your answer fully.

____

____

____

____

____

____

____ [3]

3 **(a)** State the principle of moments.

____

____

____ [2]

(b) A diagram of a lever inside a set of bathroom scales is shown in **Fig. 3.1.** The lever is 20 cm long and is fixed at one end, P. When a woman stands on the scales, her weight acts at point A, 3.0 cm from P.

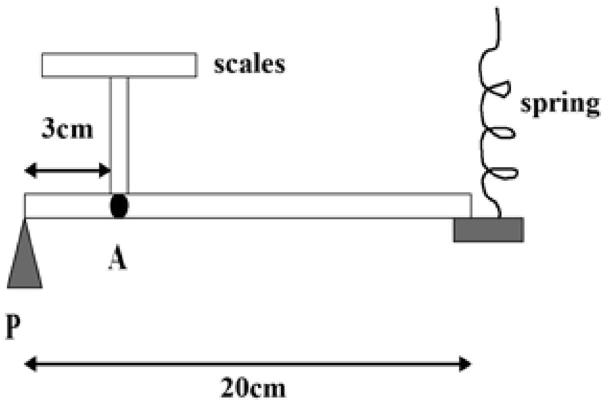


Fig. 3.1

At the right-hand end of the lever the force in the spring changes to keep the system in equilibrium. The up and down motion of the spring turns a pointer showing the weight on the outside of the scale.

(i) Draw an arrow on **Fig. 3.1** to show the force acting in the spring when the woman stands on the scales. [1]

(ii) Inside a set of scales there are four levers like the one described. The total weight on the scales is spread evenly between the four levers. The woman, of mass 75 kg, stands on the scales. Calculate the force acting on each lever. **You are advised to show your working clearly.**

Force = ______________ N [2]

(iii) Calculate the tension in the spring caused by the woman standing on the scales. Ignore the weight of the lever.
You are advised to show your working.

Tension in spring = ______________ N [2]

(iv) Calculate the spring constant of the spring if the extension of the spring is 6.0 mm when the woman stands on the scales. Remember to include the correct unit.
You are advised to show your working clearly.

Spring constant = __________________ [3]

(c) State one way in which the design of the scales could be changed so that less extension was produced in the spring when the woman stands on the scales.

____

____ [1]

4 Machines called tensile testers are used in the manufacturing of steel. The machine stretches the piece of steel until it reaches its breaking point.

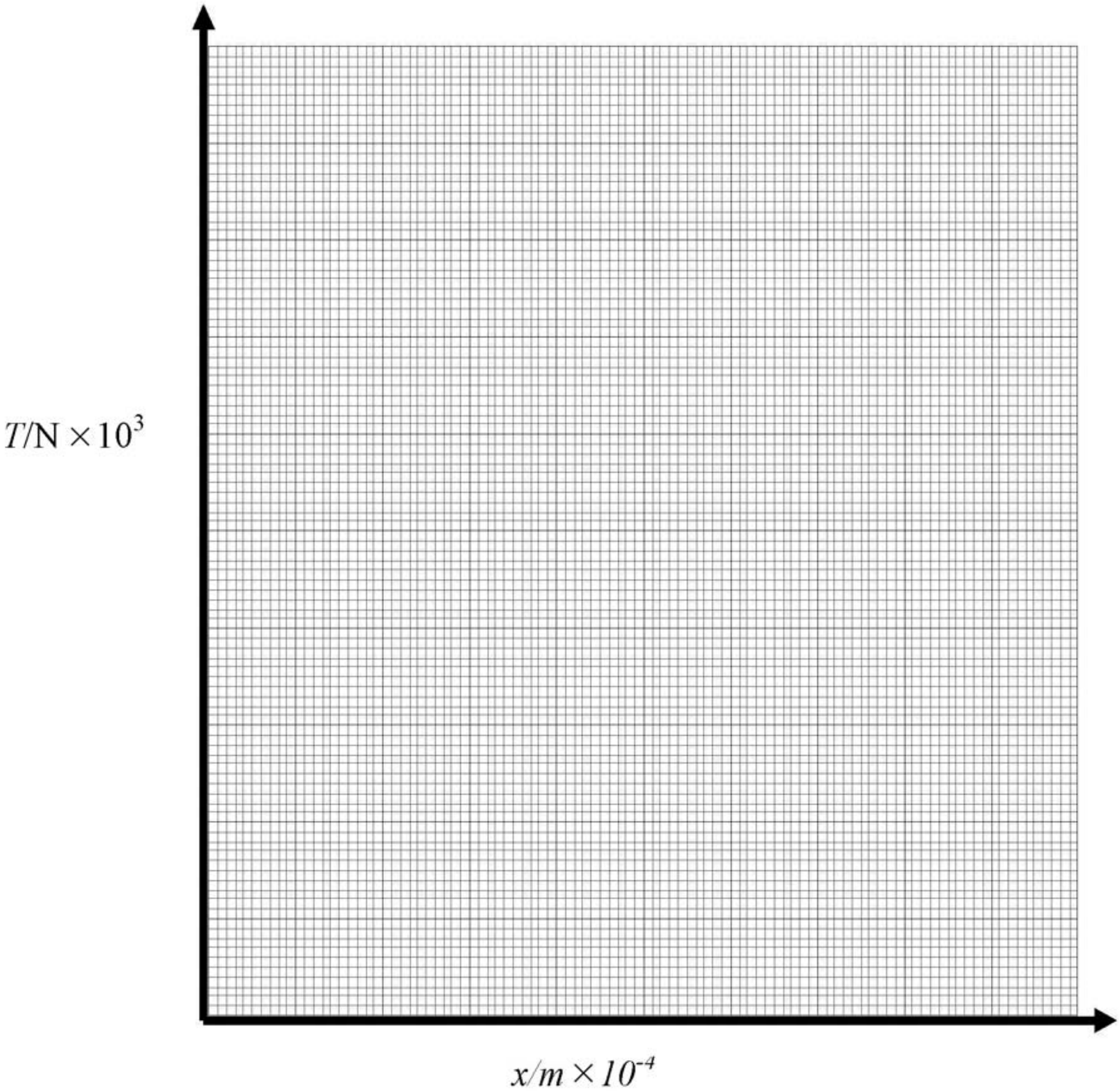
(a) What is the maximum stress that can be applied to the steel before it reaches its breaking point called?

____ [1]

(b) The tension T and resulting extension x of a sample of steel of cross-section area 2.38×10^{-5} m^2 and length 0.25 m were measured. The results are shown in Table 4.1.

T/N $\times 10^3$	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
x/m $\times 10^{-4}$	0.53	1.1	1.6	2.1	2.6	3.1	3.9	5.3	8.0

(i) Plot a graph of T against x on the grid below. [3]



(ii) Use the graph to find a value for the limit of proportionality of the steel.

Limit of proportionality _______________ m [1]

(iii) Calculate the stress in the sample of steel when the tension force is 5000 N.
You are advised to show your working clearly.

Stress = _______________ Nm^{-2} [3]

(iv) Calculate the strain in the sample of steel when the tension force is 5000 N.
You are advised to show your working clearly.

Strain = _______________ [3]

(v) Calculate the Young modulus of steel.
You are advised to show your working clearly.

Young modulus = _______________ Pa [3]

5 **(a)** State what is meant by the principle of conservation of energy.

____

____

____ [1]

(b) A gymnast of mass 55 kg hangs at rest on a high bar as shown in **Fig. 5.1.** The height of the bar above the ground is 2.80 m. The centre of mass of the gymnast is 0.90 m from her hands in the position shown.

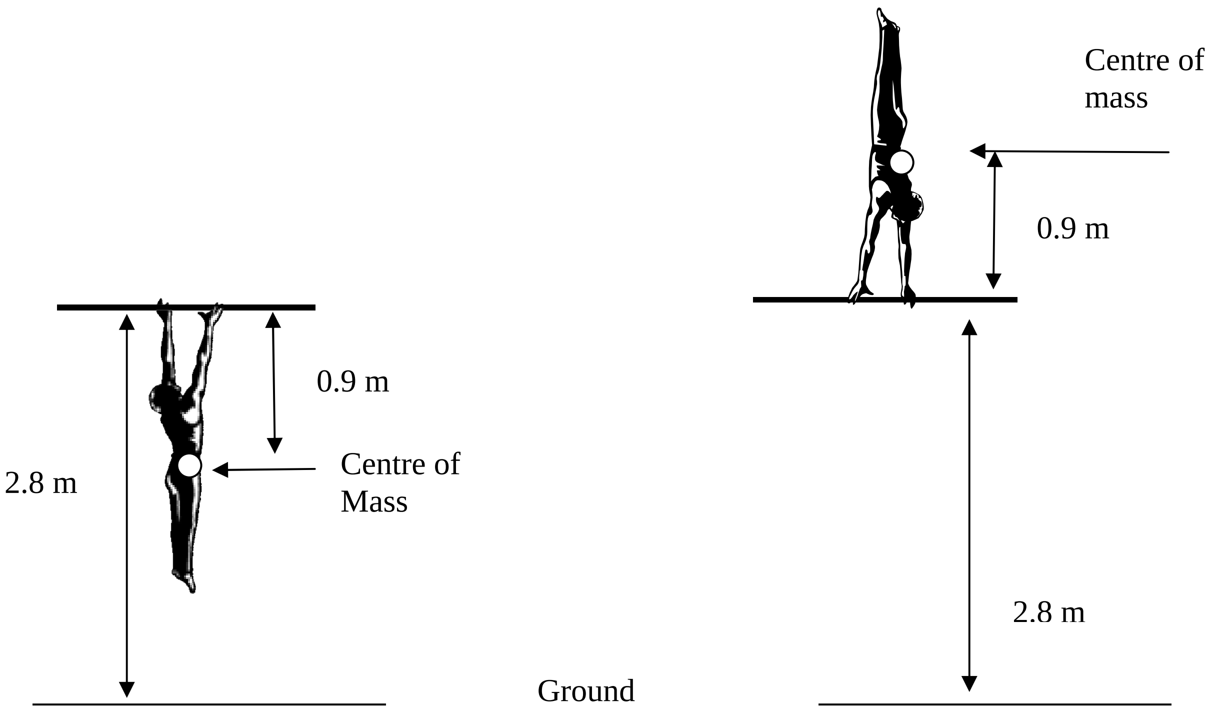


Fig. 5.1 **Fig. 5.2**

The gymnast then lifts herself to the handstand position shown in **Fig. 5.2.**

Calculate the work done by the gymnast to get to this handstand position.
You are advised to show your working clearly.

Work done = ________________ J [2]

(c) When the gymnast is at this height of 3.7 m above the ground, she loses her grip on the bar and falls vertically downwards.

(i) Use this data to calculate the speed with which the gymnast hits the ground. **You are advised to show your working clearly.**

Speed = ________________ m s^{-1} [3]

(ii) In practise, would the speed be faster or slower than what you calculated in (c)(i)? Explain your answer.

____

____

____

____

____ [2]

6 The points plotted in **Fig. 6.1** show how the current through a NTC thermistor depends on voltage across it.

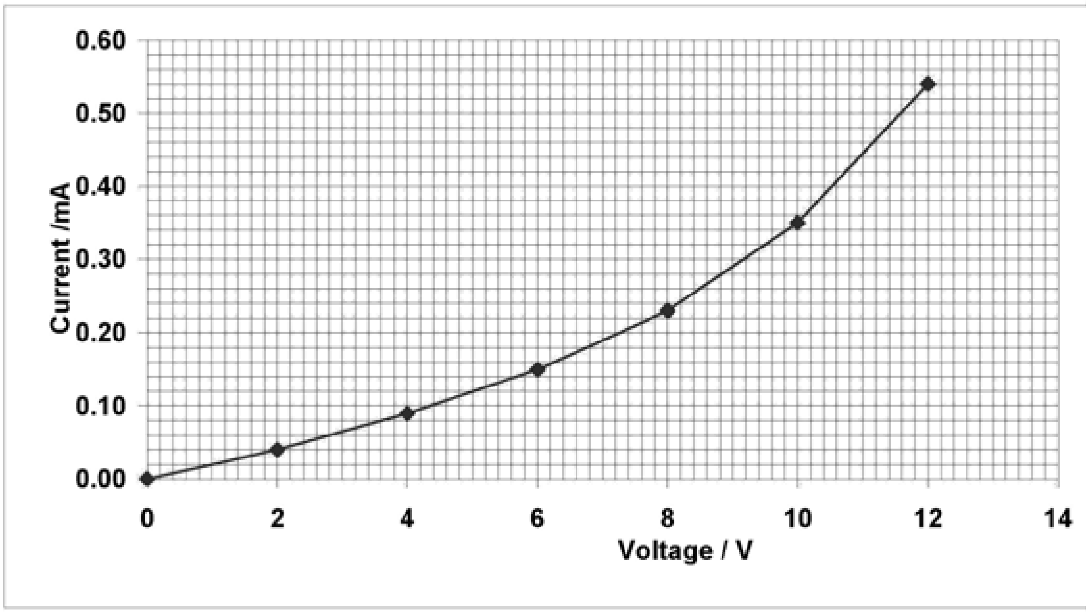


Fig. 6.1

(a) (i) Draw a circuit that could have been used to obtain the series of data plotted in **Fig. 6.1.**

Circuit diagram:

[3]

(ii) State which component in your circuit would be adjusted to obtain the series of readings.

Component to be adjusted: ______________________ [1]

(b) (i) Calculate the resistance of the thermistor at a current of 0.30 mA.
You are advised to show your working clearly.

Resistance = ________________ kΩ [3]

(ii) The thermistor in the circuit is replaced with a piece of resistance wire. Describe and explain what happens to its resistance as current increases.

[3]

7 Physicists have calculated that the European Union could reduce carbon dioxide emissions by up to 53 million tonnes if superconductors were used in power plants.

Write a short account on superconductors and their uses. You should include the following in your answer.

- A sketch showing the variation of resistance with temperature for a metal that becomes superconducting.
- A definition of what a superconductor is.
- A description of the term transition temperature.
- An explanation of why the use of superconductors in power plants could reduce carbon dioxide emissions from power plants.
- Two other examples of uses of superconductors.

[7]

Quality of written communication [2]

Centre number

71	

Candidate number

ADVANCED
General Certificate of Education
2009

Physics

Assessment Unit AS 2

Waves, Photons and Medical Physics

SPECIMEN PAPER

TIME

1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in question 2.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

1 The graph in **Fig.1.1** shows the vibration of a single particle in a medium as a wave travels past.

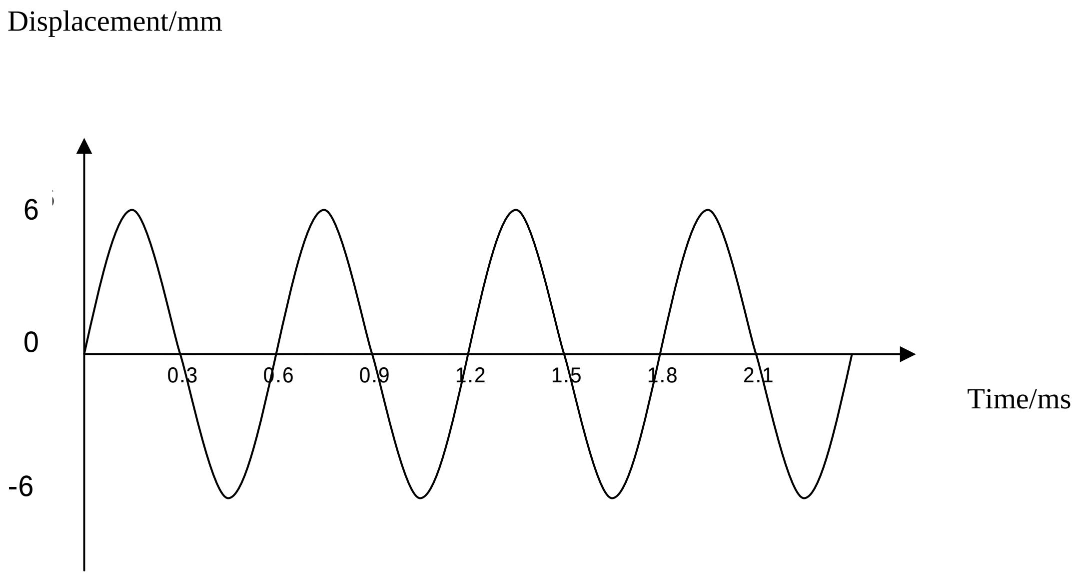


Fig. 1.1

Making use of the information from the graph, answer the following:

(a) **(i)** What is the amplitude of the vibration?

Amplitude = __________ mm [1]

(ii) What is the periodic time of the vibration?

Period = ____________ ms [1]

(iii) Calculate the speed of the wave if the wavelength is 6.2 cm.
You are advised to show your working clearly.

Speed = ____________ m s^{-1} [4]

(b) State an example of a **transverse** wave and a **longitudinal** wave.

Transverse wave = ______________________________ [1]

Longitudinal wave = ______________________________ [1]

2 In both CT scans and MRI scans the patient lies on a platform which moves into the scanner. From the patient's point of view both procedures appear very similar.

In the space below, draft a document for patients that covers the following points.

1 What MRI and CT stand for.
2 Basic principles behind each technique.
3 Potential risks or dangers.

The document should be in continuous prose.

[7]

Quality of written communication [2]

3 **(a) (i)** On **Fig. 3.1** complete the paths followed by the three rays coming from the top of the object. [3]

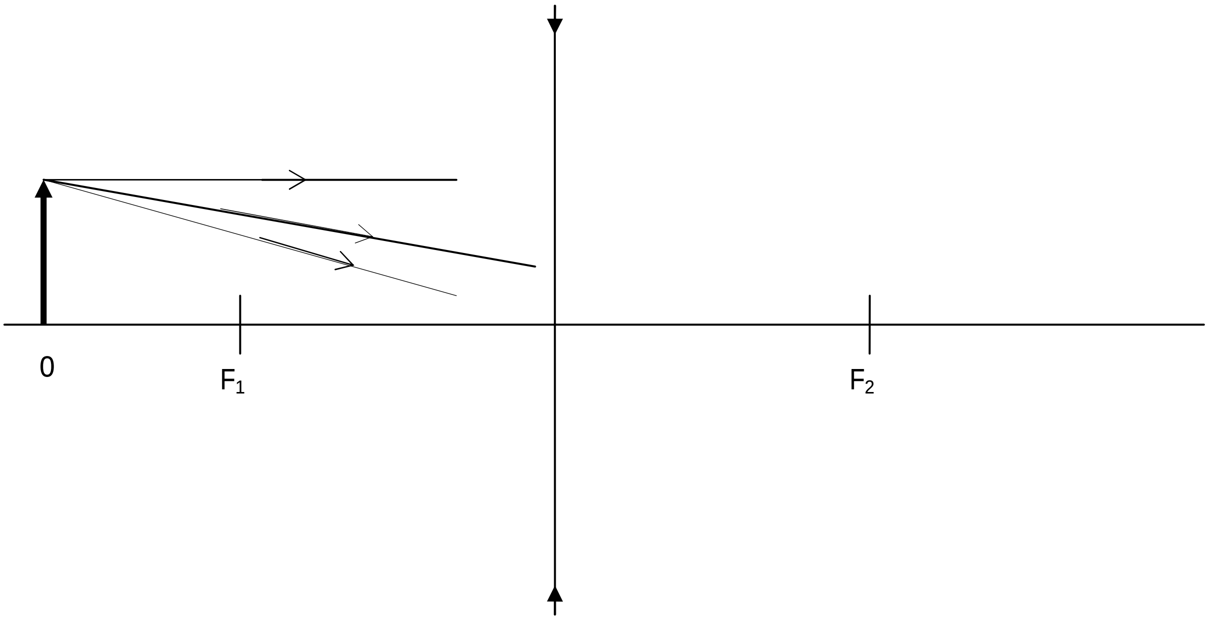


Fig. 3.1

(ii) On **Fig. 3.1**, draw an arrow to show the image formed. [1]

(b) A long-sighted person has a near point of 1.6 m. The near point of a normal eye is 0.25 m.

(i) Calculate the focal length of the converging lens needed to correct such an eye defect.
You are advised to show your working clearly.

Focal length = ______________ m [3]

(ii) Calculate the power of the converging lens used in (b)(i). Remember to include an appropriate unit.

Lens power = _____________ [1]

Unit = _____________ [1]

4 Fig. 4.1 shows the frequency response for the human ear.

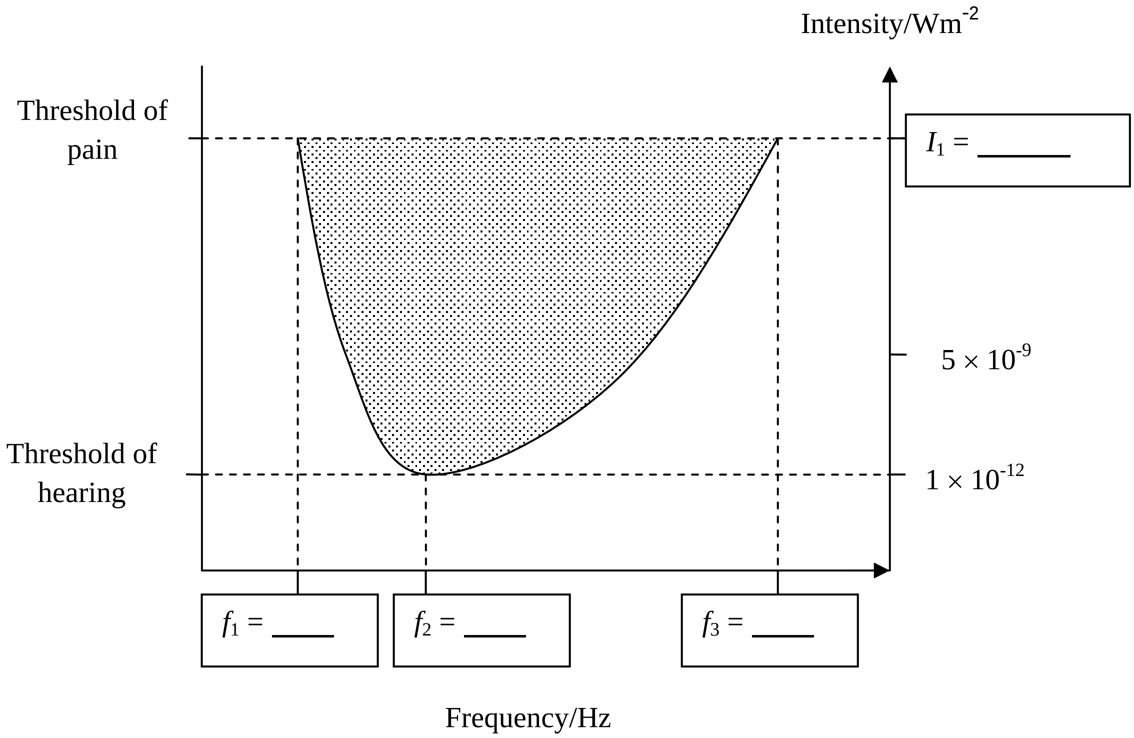


Fig. 4.1

(a) What does the shaded area represent?

____

____ [1]

(b) Insert an appropriate value for each of the values f_1, f_2, f_3 and I_1 shown on the diagram. [4]

(c) Convert the intensity 5×10^{-9} W m^{-2} into an intensity level. Remember to include the correct unit.
You are advised to show your working clearly.

Intensity level = ______________ [2]

Unit = ______________ [1]

5 In order to measure the speed of sound in air, a student is asked to set up the resonance tube experiment.

(a) Complete a labelled sketch, in the space below, of the apparatus and how it is arranged to obtain these results. The resonance tube has been included for you. [4]

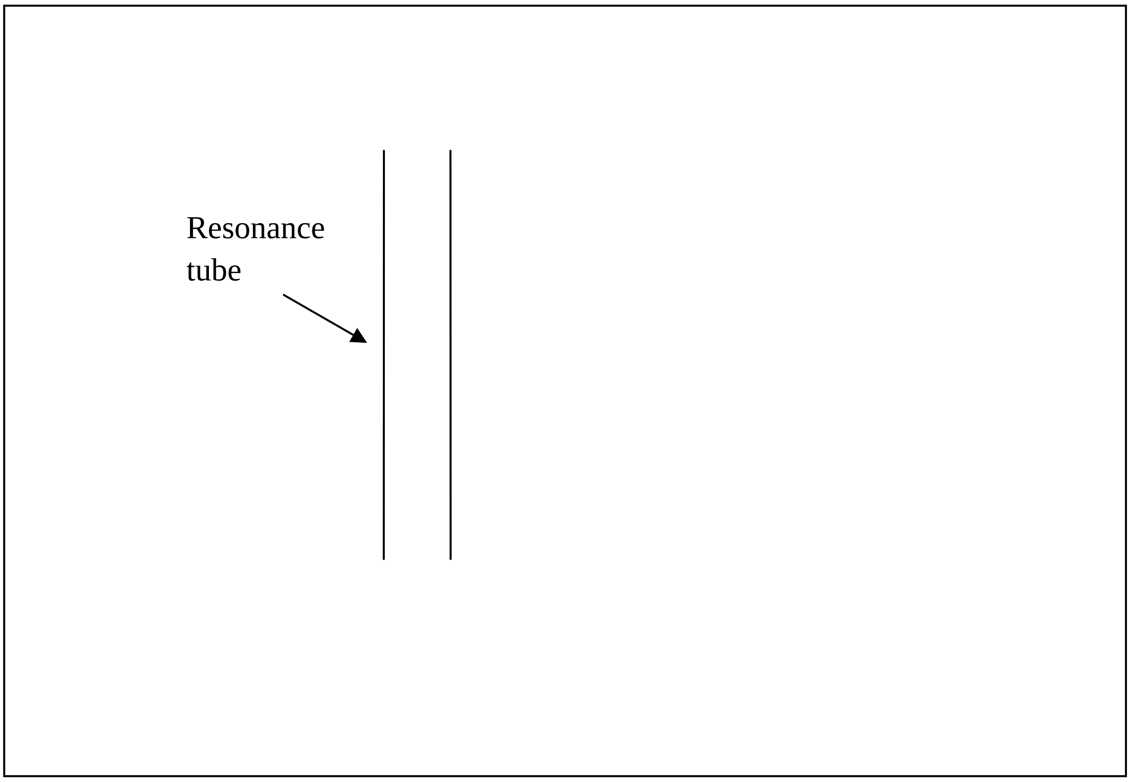


Fig. 5.1

(b) **(i)** In the resonance tube, draw the first mode of vibration. [1]

(ii) On **Fig. 5.1** mark the nodes (N) and antinodes (A). [2]

(iii) Briefly describe what a node is.

____

____ [1]

(c) Calculate the wavelength of the sound if the length of the first mode of vibration is 0.66 m.
You are advised to show your working clearly.

Wavelength = ________________m [2]

The student graphs her results as shown in **Fig. 5.2**.

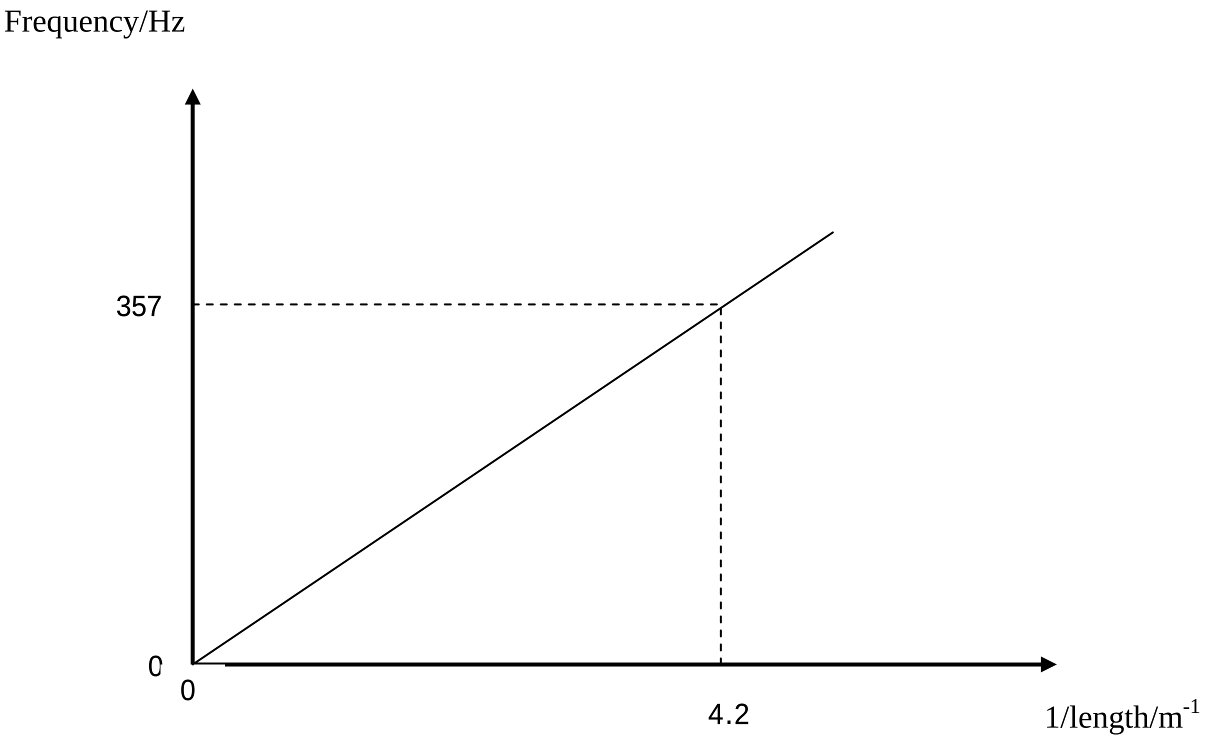


Fig. 5.2

(d) Use the graph to calculate the speed of sound in air.
You are advised to show your working clearly.

Speed of sound = ____________________ m s^{-1} [4]

6

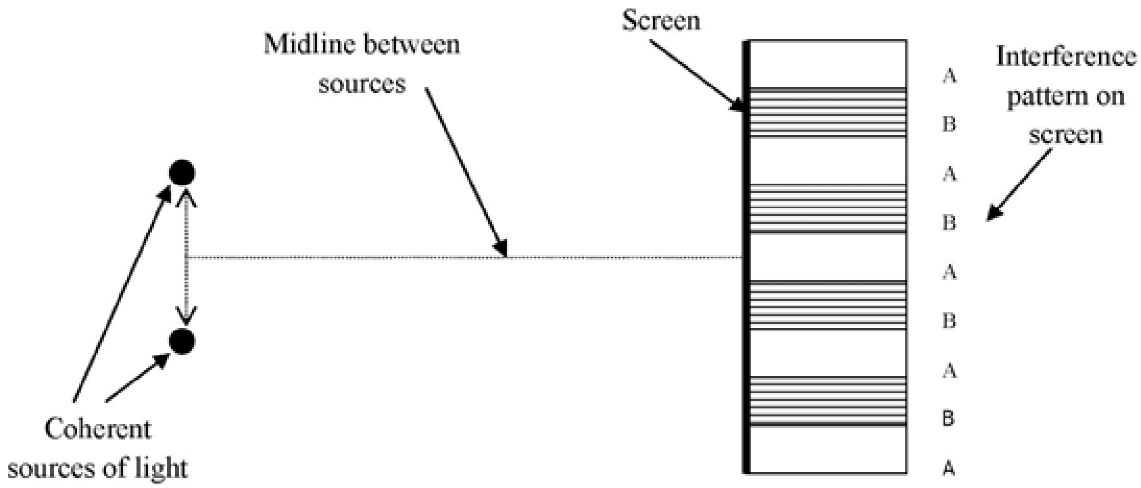


Fig. 6.1

Fig. 6.1 shows two things:

1 a simplified arrangement for a double source interference experiment using light;

2 a typical interference pattern obtained from such an experiment.

(a) **(i)** What is meant by coherent sources of light?

____ [1]

(ii) Apart from being coherent sources, what other feature must the sources have in order to produce an observable interference pattern?

Feature = ______________________________ [1]

(b) A phase difference of π rad (phase angle 180°) exists between the light emitted from each source. Which section on the interference (fringe) pattern represents **destructive interference**? Explain your answer.

Answer by ticking the appropriate box below.

Regions labelled A ❑

Regions labelled B ❑

[1]

Explanation

____

____ [2]

(c) Calculate the distance between the centre of one bright fringe and the centre of the next bright fringe if the light has a wavelength of 550 nm, the sources are 0.2 mm apart, and the distance between the slits and the screen is 4 m.
You are advised to show your working clearly.

Fringe separation = ______________ mm [4]

7 The photoelectric effect is the ejection of electrons from a metal as a result of electromagnetic waves shining on the metal surface.

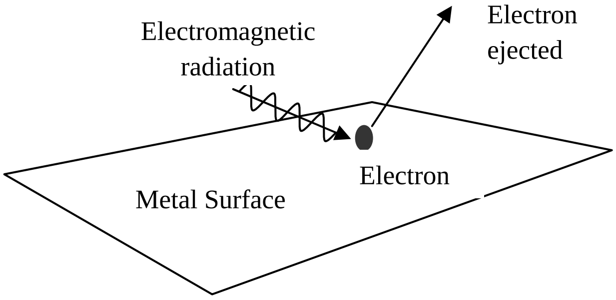


Fig. 7.1

(a) Explain why electromagnetic radiation of less than a certain frequency is unable to cause photoelectric emission from a metal surface.

____

____

____

____ [3]

(b) **(i)** The work function of the metal is 6.9×10^{-19} J.
Calculate the minimum frequency of electromagnetic wave that could cause photoelectric emission.
You are advised to show your working clearly.

Frequency = ________________ Hz [3]

(ii) Hence calculate the maximum wavelength of the electromagnetic wave.

Wavelength = ________________ m [1]

(iii) An electron at the surface of the metal is emitted with a kinetic energy of 4.5×10^{-19} J. How much energy did the electromagnetic radiation transfer to the electron?

Transferred energy = ________________ J [1]

8 **(a)** Complete the wavefront diagrams in Figs 8.1 and 8.2 to show **diffraction**.

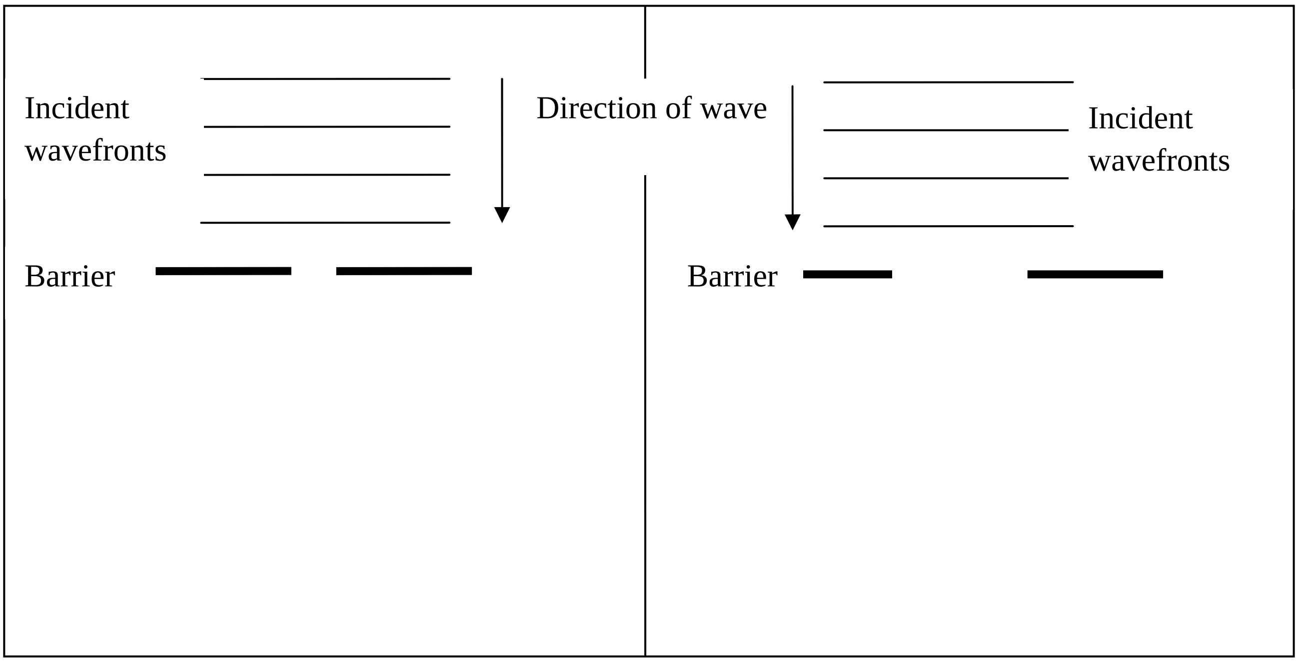


Fig. 8.1 **Fig. 8.2**

[4]

Electrons can be diffracted. **Figs. 8.3 and 8.4** represent electron diffraction patterns for two different crystalline solids with similar molecular arrangements.

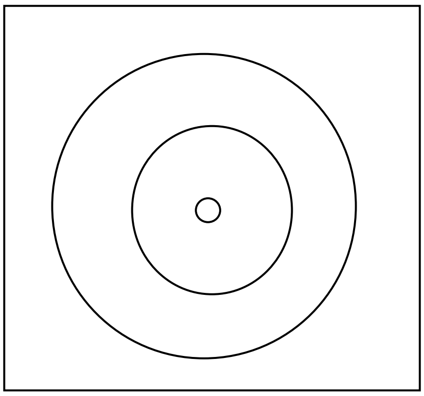


Fig. 8.3

Electron micrograph A

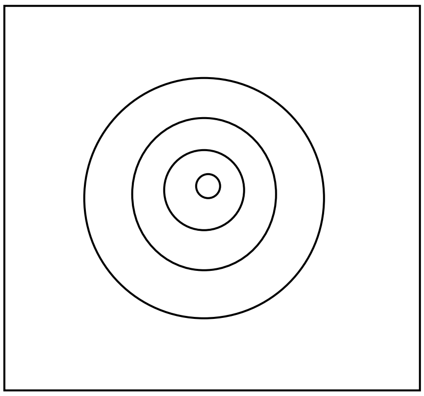


Fig 8.4

Electron micrograph B

(b) The micrographs were obtained under identical experimental conditions. What can you deduce about the molecular separation in the two crystalline solids?

Explain your deduction.

Deduction:

____

____ [1]

Explanation:

____

____

____ [2]

(c) An electron microscope is to be used to study the molecular structure of a metal alloy. Theory has predicted the electron wavelength will be 0.54 nm.

Calculate the minimum speed to which the electrons have to be accelerated in order to be used in this application.
You are advised to show your working clearly.

Speed = ________________ m s^{-1} [3]

Centre number	
71	

Candidate number

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Physics

Assessment Unit AS 3

Practical Techniques (Internal Assessment)

SPECIMEN PAPER

TIME

1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all** questions in this paper, using this booklet. Rough work and calculations must also be done in this booklet. Except where instructed, do not describe the apparatus or the experimental procedures.

The supervisor will tell you the order in which you are to answer the questions. One hour is to be spent on Section A and 30 minutes on Section B. You may be told to start with the tests in Section A, or with the single question in Section B.

Section A consists of four short experimental tests. A 14-minute period is allocated to each of these tests. At the end of this period you will be instructed to move to the area set aside for Section B. Section B consists of one question in which you will analyse a set of experimental results.

INFORMATION FOR CANDIDATES

The total mark for this paper is 40.
Section A and Section B carry 20 marks each.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each part question.
You may use an electronic calculator.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
Total Marks	

Section A

1 In this experiment you are to measure the diameter of the body of a drinks can.

(a) (i) Obtain an estimate of the diameter of the body of the can by laying the 30 cm rule provided across the top of the can and taking a measurement.

Diameter = ________________ mm [1]

(ii) Explain why this value is only an estimate.

____

____ [1]

(b) Use the piece of string and the metre rule provided to obtain a better estimate of the diameter of the body of the can.
You are advised to show your working clearly.

Diameter = ________________ mm [3]

2 In this experiment you are to obtain a value for the period of oscillation of a hacksaw blade that is loaded with a mass at one end. **Fig. 2.1** shows the arrangement of the apparatus, which is already set up for you.

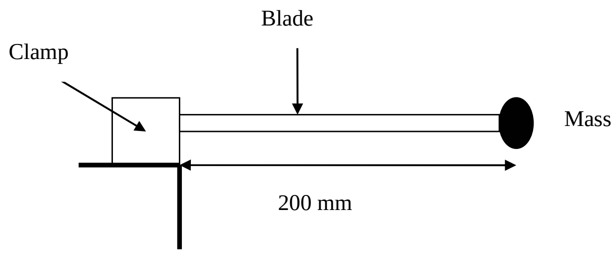

Fig. 2.1

(a) Pull the mass about 2 cm to one side and release it so that it oscillates. Take measurements to determine the period of oscillation *T*.
You are advised to show your working clearly.

T = ______________ s [3]

(b) Reduce the length *L* of the blade until it is too short to determine a reliable value of the period. Record this value L_{min} of the length. Explain how you decided that it was no longer possible to determine a reliable value of the period.

L_{min} = ____________mm [1]

Explanation:

____

____ [1]

3 In this experiment you are to use a converging lens to obtain a focused image of an object. The apparatus has been set up as shown in **Fig. 3.1.**

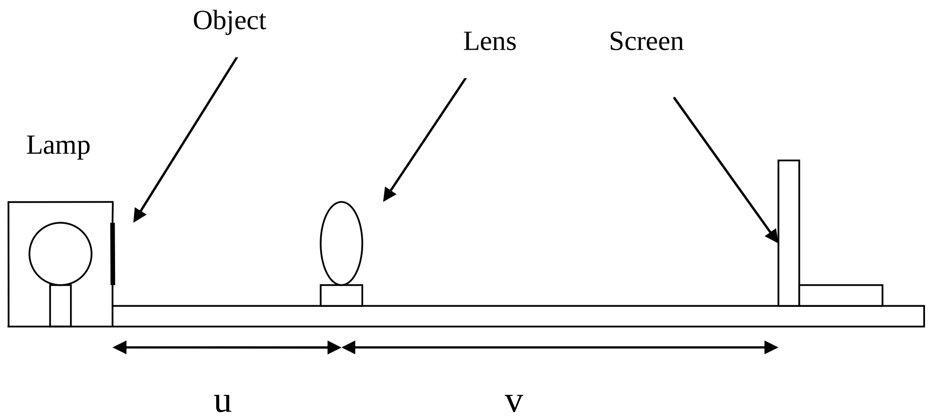

Fig. 3.1

(a) (i) Move the screen until a focused image of the object is obtained on it. Record below the distance *v* of the screen from the lens.

Image distance = ____________mm [1]

(ii) Estimate the uncertainty in your value of *v*, and explain how this uncertainty arises.

Uncertainty in *v* = ± _________ mm [1]

Explanation:

____

____

____ [1]

(b) The focal length *f* of the lens is given by $1/u + 1/v = 1/f$.

Use your value of the image distance to calculate the focal length of the lens. Remember the object distance was 200 mm.

Focal length *f* = _______________ mm [2]

4 In this experiment you will measure the resistance of an unknown resistor X.

(a) Set up the circuit shown in **Fig. 4.1** [1]

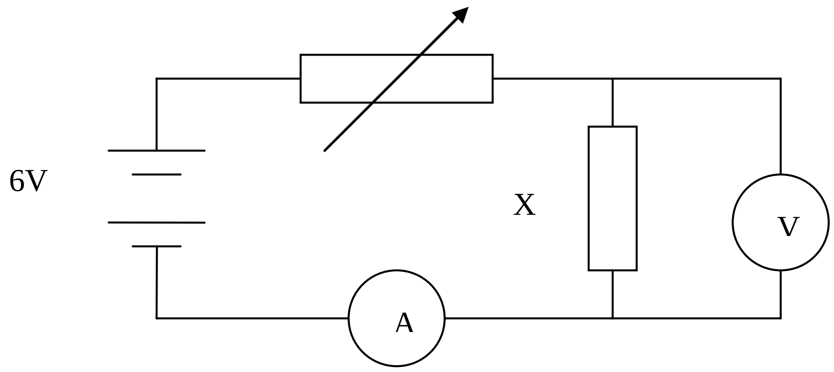

Fig 4.1

If you have difficulty in setting up a working circuit, you may ask for assistance. A deduction of 1 mark will be made.

(b) (i) Adjust the variable resistor so as to obtain a current *I* of 0.20 A in the circuit. In **Table 4.1**, record the value *V* of the potential difference across the unknown resistor. Calculate the value of the resistance *R* of the unknown resistor, and record this in the third column of the table.

I/A	*V*/V	*R*/Ω
0.20		
0.40		
0.60		

[3]

Table 4.1

(ii) Repeat this procedure for currents *I* of 0.40 A and 0.60 A. Record all your results in **Table 4.1**.

(c) Calculate the average R_{av} of your three values of *R*.

R_{av} = ________________ Ω [1]

Section B

5 E.m.f. and Internal Resistance

A student uses the circuit shown in **Fig. 5.1** to determine the e.m.f.. *E* and the internal resistance *r* of a cell.

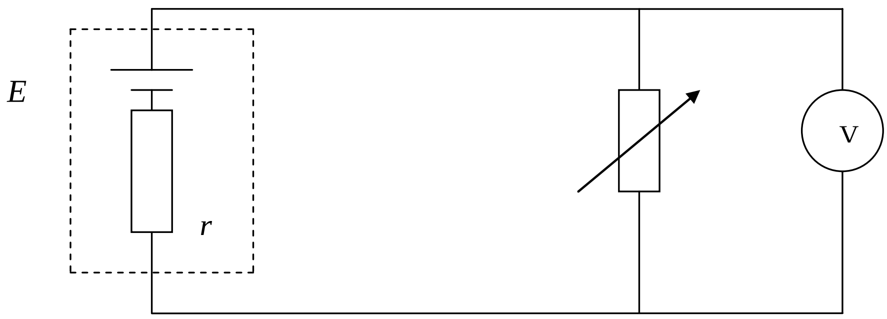

Fig 5.1

The variable resistor can be set to known values *R*. The voltmeter measures the potential difference *V* across the resistor. This is the same as the terminal potential difference of the cell. The student takes a set of values of *V* corresponding to different values of *R*. He records the results in **Table 5.1**.

R/Ω	*V*/V	*x*-axis ________	*y*-axis ________
0.15	0.35		
0.25	0.51		
0.50	0.77		
1.00	1.03		
1.50	1.17		
2.00	1.25		

Table 5.1

The student plans to use the equation:

$$\frac{1}{V} = \frac{r}{ER} + \frac{1}{E}$$ **Equation 5.1**

to use a graphical method to obtain the values of *E* and *r*.

(a) Theory

(i) What graph should be plotted so as to give a straight line from which E and r can be obtained? State the horizontal and vertical axes.

Horizontal (x-) axis: ________________ [1]

Vertical (y-) axis: ________________ [1]

(ii) Show how the values of E and r are related to the gradient and intercept of the graph in **(i)**.

Gradient of graph: ____________ [1]

Intercept of graph: ____________ [1]

If you are unable to work out what graph is required, or how to use it to find *E* and *r*, you may ask for assistance. A deduction of up to 4 marks will be made.

(b) Data processing

(i) Head the third and fourth columns of **Table 5.1** with the quantities that should be calculated for the x- and y-axes for the graph in **(a)(i)**. Include appropriate units. [2]

(ii) Calculate the values for the third and fourth columns of **Table 5.1**. Record them in **Table 5.1**. [2]

(iii) On the grid of **Fig. 5.2**, draw the graph of the processed data in **Table 5.1**. Label the axes and choose suitable scales. Plot the points and draw the best straight line through them. [4]

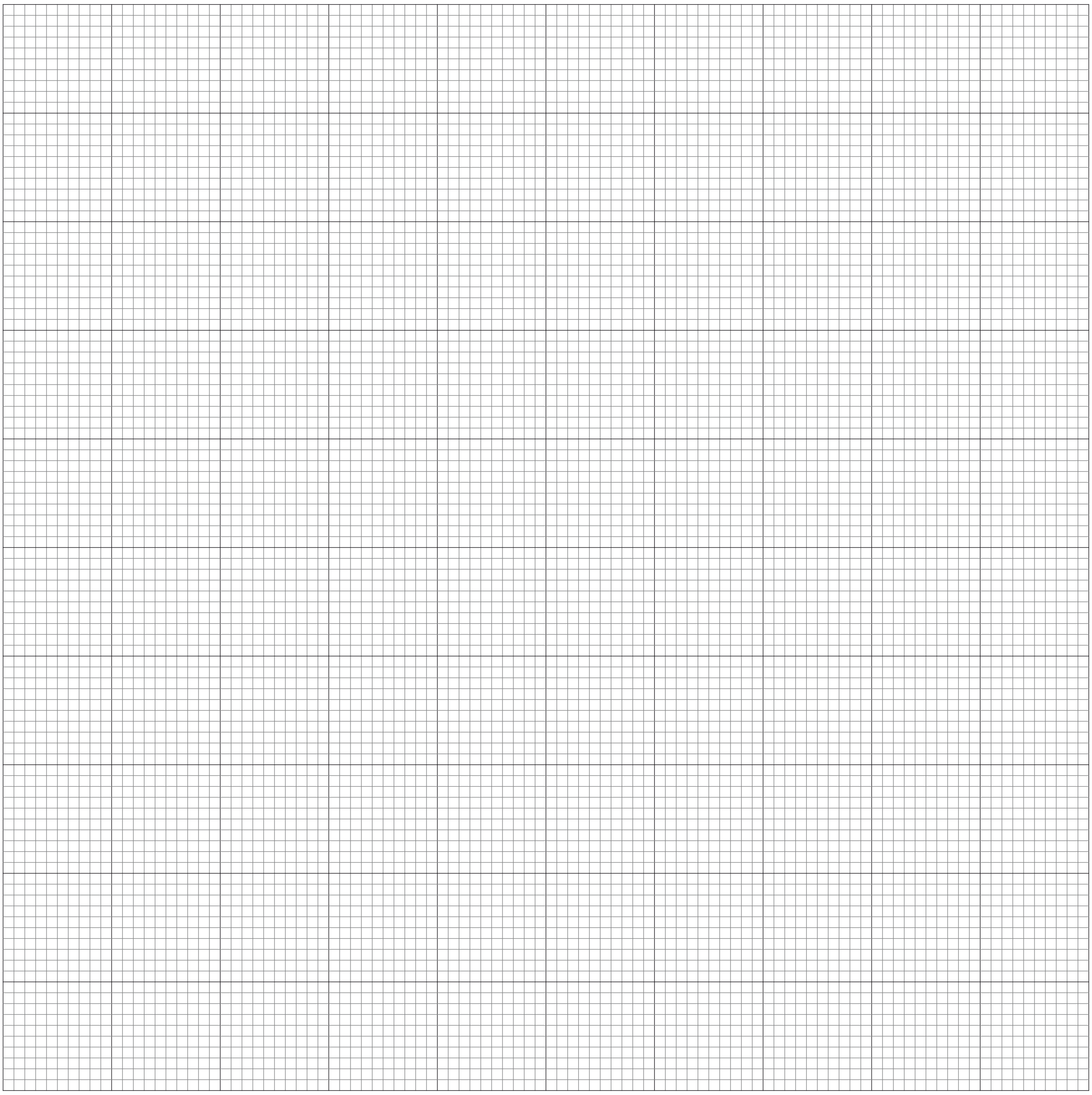

Fig. 5.2

(c) Analysis

(i) Measure the gradient of the graph. Include an appropriate unit.

Gradient = ____________________ Unit: ____________________ [2]

(ii) Measure the *y*-intercept of the graph. Include an appropriate unit.

y-intercept = __________________ Unit: ____________________ [2]

(iii) Hence calculate the values of E and r.

E = ______________ V [1]

r = ______________ Ω [1]

(d) Evaluation

The voltmeter used in **Fig. 5.1** must have a very high resistance.

(i) Explain why this is necessary.

____

____ [1]

(ii) The student has used an unsuitable spacing for the values of resistance R.

Explain why the spacing of the values is unsuitable.

____

____ [1]

ADVANCED SUBSIDIARY (AS)
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2010

Physics

Assessment Unit AS 3

Practical Techniques (Internal Assessment)

CONFIDENTIAL INSTRUCTIONS FOR AS 3 PRACTICAL TEST

Question 1

Requirements

1 Empty aluminium drinks can, diameter of body 68 mm.
2 Fine string, 0.5 m length.
3 Half-metre rule.
4 30 cm rule.

Preparation

Lay the apparatus on the bench.

Action at changeover

None.

Question 2

Requirements

1 Hacksaw blade.
2 200 g mass.
3 Wooden blocks, 2.
4 G-clamps, 2.
5 Stopwatch or stopclock reading to 0.1 s or better.
6 Half-metre rule.

Preparation

Cover the teeth of the hacksaw blade with sellotape. Bolt, or attach firmly with sellotape, the 200 g mass to one end of the blade. Clamp the blade between the wooden blocks and clamp the blocks to the edge of the bench so that it projects horizontally, as shown in **Fig. 2.1**, with a projecting length of 200 mm.

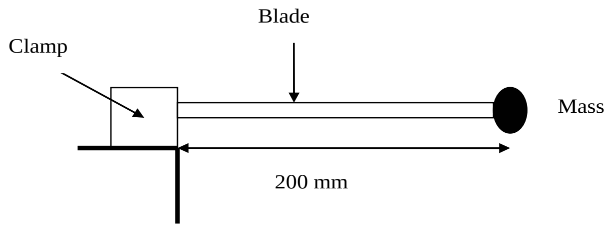

Fig. 2.1

Check that, when the mass at the end of the blade is drawn to one side and released, it oscillates freely in a horizontal plane.

Leave the stopwatch or stopclock and the half-metre rule on the bench close to the clamped blade.

Action at changeover

Restore the oscillating length of the blade to 200 mm.

Question 3

Requirements

1 Converging lens, focal length 150 mm.
2 Simple optical bench consisting of metre rule taped to bench, illuminated object, screen, and lens holder.

Preparation

Place the lens in its holder and ensure that the illuminated object is on the axis of the lens.

Testing

Check that when the lens is placed at a distance of 200 mm from the illuminated object a focused image can be obtained on the screen at a lens-screen distance of about 600 mm.

Action at changeover

Adjust object distance (u) to be 200 mm.

Question 4

Requirements

1 4.7 Ω resistor, mounted in holder.
2 3.0 V d.c. source (2 × 1.5 V cells in holder).
3 0 – 5 V d.c. voltmeter, analogue or digital.
4 0 – 1 A d.c ammeter, analogue or digital.
5 0 – 20 Ω variable resistor (potentiometer).
6 Connecting wire.

Preparation

Conceal any value markings on the 4.7 Ω resistor.

Lay the circuit components on the bench.

During the examination

If, and only if, the candidate asks for assistance, connect the circuit shown in **Fig. 4.1**.

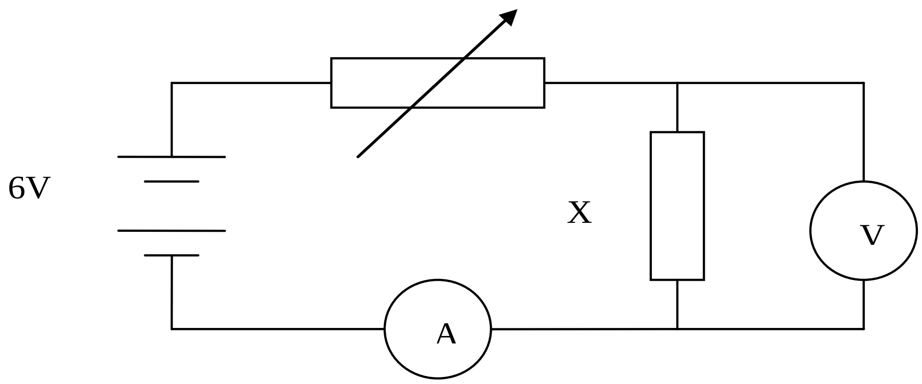

Fig. 4.1

Award the candidate 0 marks for part 4(a).

Action at changeover

Disconnect the candidate’s circuit.

Question 5

If, and only if, the candidate asks for assistance in part 5(a)(i), inform the candidate:

> "The horizontal axis is $1/R$;
> the vertical axis is $1/V$."

Award the candidate 0 marks for part 5(a)(i).

If, and only if, the candidate asks for assistance in part 5 (a)(ii), inform the candidate:

> "The slope of the graph is r/E;
> the *y*-intercept is $1/E$."

Award the candidate 0 marks for part 5(a)(ii).

Centre number

71	

Candidate number

Rewarding Learning

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Physics

Assessment Unit A2 1

Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

SPECIMEN PAPER

TIME

1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in question 7.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.
Question 8 contributes to the synoptic assessment required of the specification.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

1 **(a)** State the principle of conservation of momentum.

____

____

____ [2]

(b) **Fig. 2.1** is a graph showing the change in momentum of a car A of mass 1200 kg involved in a collision at time t = 20 s.

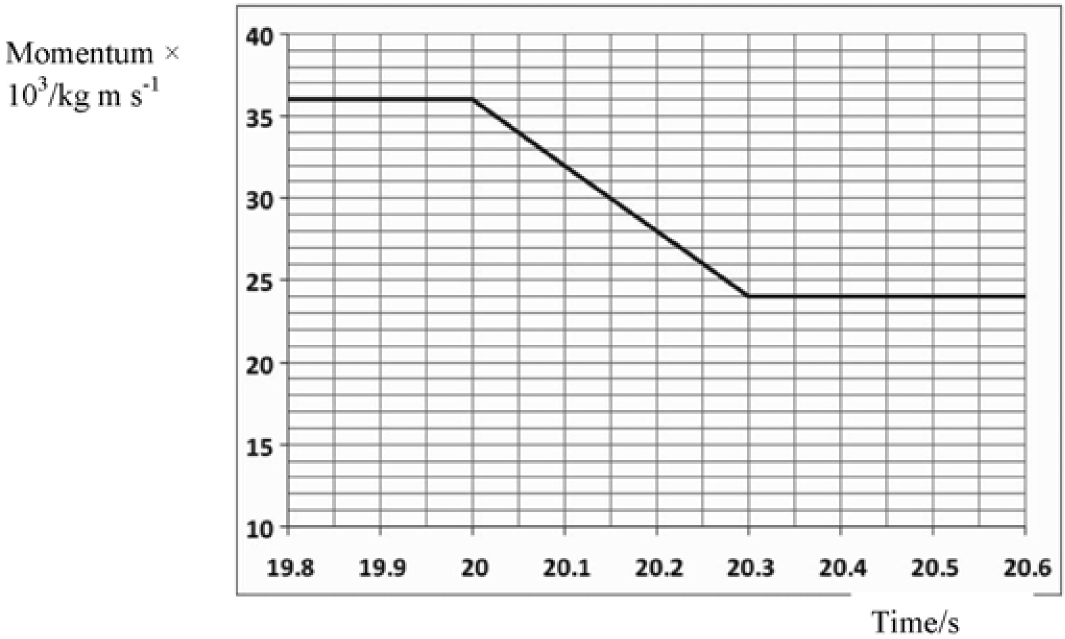

Fig. 1.1

(i) Calculate the velocity of the car before the collision.

Velocity before collision ________________ m s^{-1} [2]

(ii) Calculate the velocity of the car immediately after the collision.

Velocity after collision ________________ m s^{-1} [1]

The car collided head on with a motorcyclist of mass 250 kg travelling in the opposite direction at a constant speed of 20 m s^{-1}.

(iii) Calculate the speed of the motorcyclist immediately after the collision and state its direction.

Speed = ______________ m s^{-1}

Direction __________________ [4]

(iv) State and explain whether the collision was inelastic or elastic.

____

____

____

____

____ [3]

2 **(a)** Describe how the pressure that gas molecules exert on the walls of a container changes when the temperature of the gas increases. Explain your answer.

____

____

____

____

____

____

____

____ [4]

(b) A cylinder has a fixed volume of 1.36×10^{-3} m^3 and contains a gas at a pressure of 1.04×10^5 Pa when the temperature is 15°C.

(i) Calculate the number of gas molecules in the container.

Number of molecules ______________ [5]

(ii) Calculate the new pressure of the gas when the temperature is increased to 25°C.

Pressure = ______________ Pa [3]

(iii) Calculate the increase in kinetic energy of **all** the gas molecules in the container caused when the temperature is increased to 25°C.

Increase in kinetic energy = _____________ J [3]

3 **(a)** Define simple harmonic motion.

____

____

____ [2]

(b) The head of an electric toothbrush oscillates in simple harmonic motion. The period of oscillation for the head of one toothbrush is 0.16 ms.

(i) Calculate the angular frequency of the oscillation.

Angular frequency _______________ rad s^{-1} [2]

When it is vibrating, the head moves a maximum distance of 0.60 mm from its rest position.

(ii) Calculate its maximum acceleration.

Maximum acceleration = _____________ m s^{-2} [3]

(c) **Fig. 2.1** shows how the displacement of the toothbrush head varies with time.

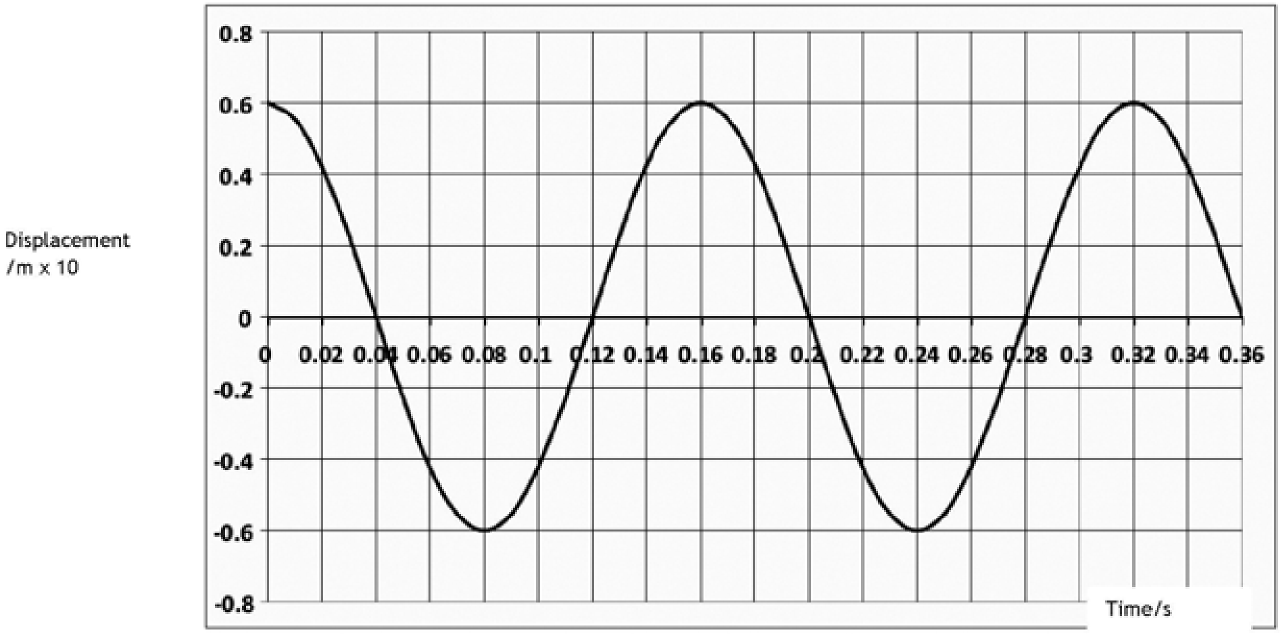

Fig.2.1

Sketch on **Fig. 2.2** how the velocity varies with time.
Do not insert numerical values on the *y*-axis. [3]

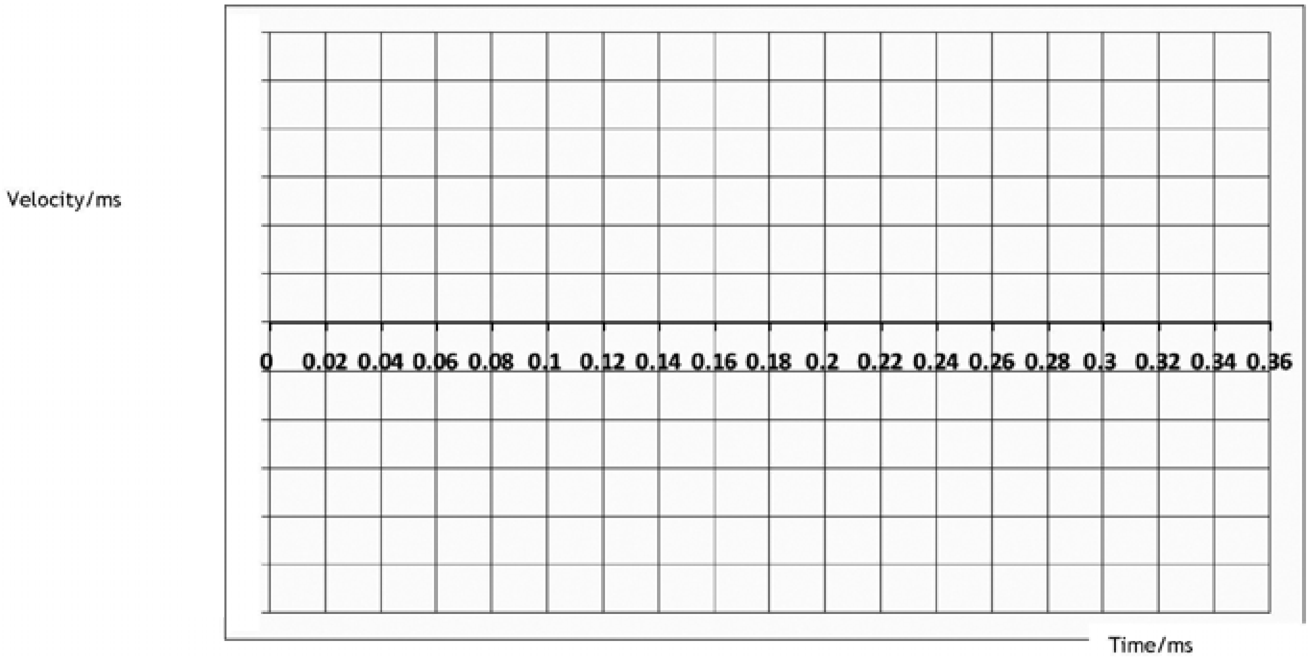

Fig. 2.2

4 A DVD rotating inside a player **must** maintain a constant linear velocity of 3.84 m s^{-1} in order for the information on it to be read correctly. The laser in the DVD player starts at the inside of the disc and moves outwards.

(a) (i) State and explain what must happen to the angular velocity of the disc as the DVD is played.

____

____

____ [2]

(ii) Calculate the radius at which the DVD will have an angular velocity of 14.6 revolutions per second when the linear velocity is 3.84 m s^{-1}.

r = _____________ cm [3]

The linear velocity of a CD is 1.3 m s^{-1} compared to the value of 3.84 m s^{-1} for a DVD.

(b) Explain whether dust particles are more likely to remain on a CD or a DVD when the discs are in motion.

Assume that the maximum frictional force between a dust particle and DVD is the same as between a dust particle and CD.

____

____

____

____

____

____

____ [4]

5 **(a)** The nuclear model of the atom was confirmed by alpha particle scattering experiments. Outline the **experimental observations** obtained from alpha particle scattering experiments and the **conclusions** about the structure of the atom that these observations led to.

____

____

____

____

____

____

____

____

____ [4]

(b) **Table 5.1** shows the nuclear radii for some elements calculated from scattering experiments.

Table 5.1

Nucleus	**Mass Number**	**Radius × 10^{-15} m**
Helium	4	2.08
Carbon	12	3.04
Silicon	28	3.92

(i) The radii are related to the mass number by the equation $r = r_0 A^{1/3}$ where r_0 is a constant. Calculate a value for r_0.

r_0 = ________________ m [2].

(ii) The results shown in **Table 5.1** are to be displayed on a graph. What quantities should be plotted on the *y*-axis and the *x*-axis in order to achieve a straight line graph?

y-axis: ____________________

x-axis: ____________________ [2]

(iii) State the gradient of the graph you would draw.

____ [1]

(iv) State the intercept on the *y*-axis of your graph.

____ [1]

6 A smoke detector contains radioactive americium-241. Americium decays releasing alpha particles. The alpha particles generated by the americium ionize the air molecules in the chamber of the smoke detector.

(a) Explain why the alpha particles emitted by smoke detectors are not a health hazard to us in our homes.

____

____ [1]

(b) Describe fully what ionization is and explain why alpha particles cause much more ionization than beta particles.

____

____

____

____

____ [3]

(c) The becquerel (Bq) is the unit of activity of a radioactive source. What is meant by the **activity** of a radioactive source?

____

____ [1]

(d) The half life of radioactive Americium is 432 years. A new smoke detector contains radioactive Americium with an activity of 35kBq.

Calculate the decay constant (λ) of the source and use this to find the activity of the radioactive Americium after 30 years.

Decay constant λ________________ yr^{-1}

Activity ___________ kBq [4]

7 **Figure 6.1** shows the relationship between the nuclear binding energy per nucleon and the nucleon number.

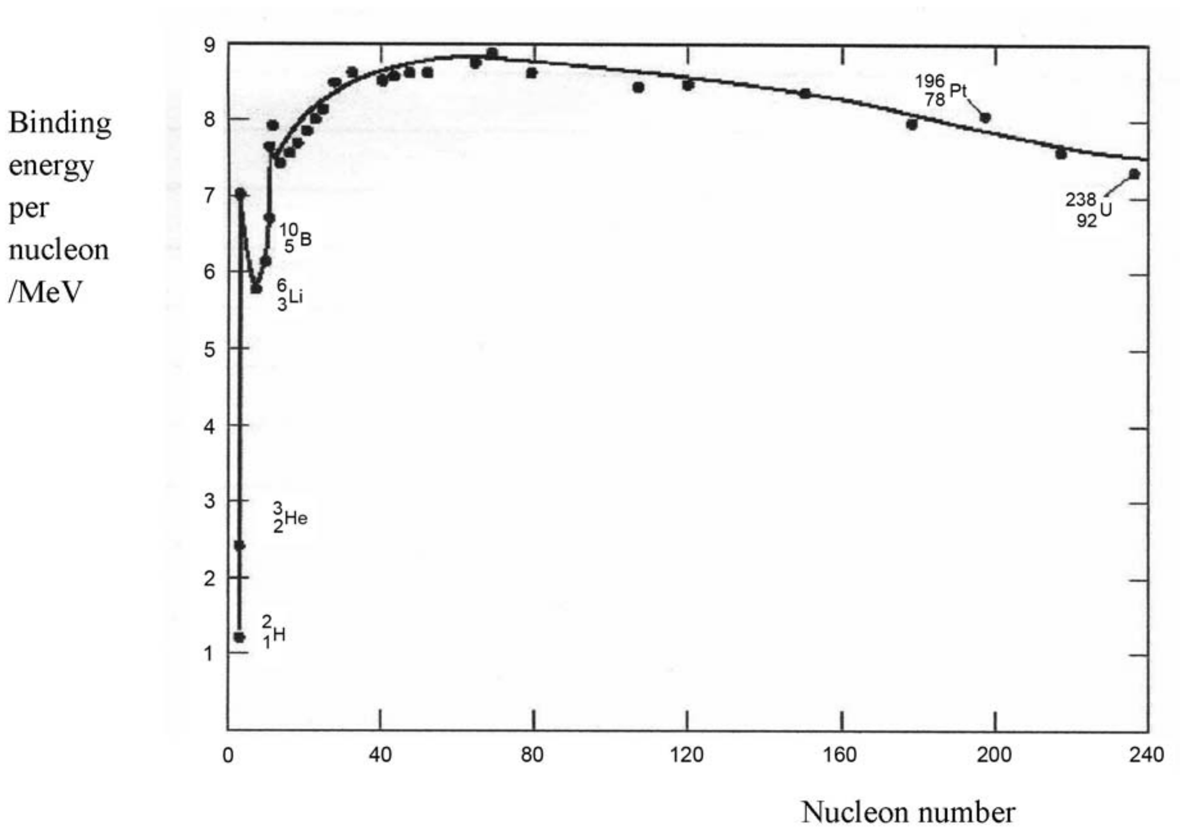

Fig. 7.1

(a) With reference to **Figure 7.1**, compare and contrast the principles of nuclear fission and fusion.

You should include in your answer:

- A description of what fission and fusion are.
- Which nuclides on the graph undergo fission and fusion and why they undergo these processes.
- A comparison of the energy released when heavy nuclei undergo fission and when light nuclei undergo fusion.

[6]

Quality of written communication [2]

(b) It is currently possible to use nuclear fission to produce energy on a large scale. Explain why it is so difficult to achieve fusion on a large scale at present.

[2]

8 Data Analysis Question

This question contributes to the synoptic assessment requirement of the specification. In your answer you will be expected to bring together and apply principles and contexts from different areas of physics, and to use the skills of physics in the particular situation described.

Speed measurement using a Pitot-static tube

Pitot-static tubes are used on aircraft as speedometers. The Pitot-static tube is mounted on the aircraft so that the centre tube is always pointed in the direction of travel and the outside holes are perpendicular to the centre tube.

Since the outside holes are perpendicular to the direction of travel, these tubes are pressurised by the normal air pressure. The pressure in these tubes is the static pressure P_s. The centre tube, however, is pointed in the direction of travel and is pressurised by both the normal air pressure and the air velocity. The pressure in this tube is the total pressure P_t. The difference in total and static pressure is the dynamic pressure q.

$$q = P_t - P_s$$

(a) The total pressure, P_t, increases as the velocity of the aircraft increases. State and explain whether the Pitot-static tube will give a more accurate reading at high or low aircraft velocities.

____

____

____

____

____

____

____ [3]

(b) With the difference in pressures measured and knowing the local value of air density ρ, the velocity is given by **Equation 8.1**:

$$q = \frac{1}{2}\rho v^n \quad \textbf{Equation 8.1}$$

Table 8.1 shows the values of dynamic pressure, q, measured by a Pitot-static tube when an aircraft is moving with velocity v.

Table 8.1

v/m s^{-1}	q/N m^{-2}	log (v/m s^{-1})	log (q/N m^{-2})
80	2902		
90	3689		
100	4470		
110	5507		
120	6408		

It is possible to obtain a value for n by plotting a logarithmic graph. Taking logarithms to the base 10 of each side of **Equation 8.1** leads to **Equation 8.2**.

$$\log q = \log \frac{\rho}{2} + n \log v \quad \textbf{Equation 8.2}$$

(i) Calculate values of log q and log v and insert them into the remaining columns of **Table 8.1**. [2]

(ii) On **Fig. 8.1**, plot a suitable linear graph from which you will be able to obtain a value for n. Draw the best straight line through the points. [5]

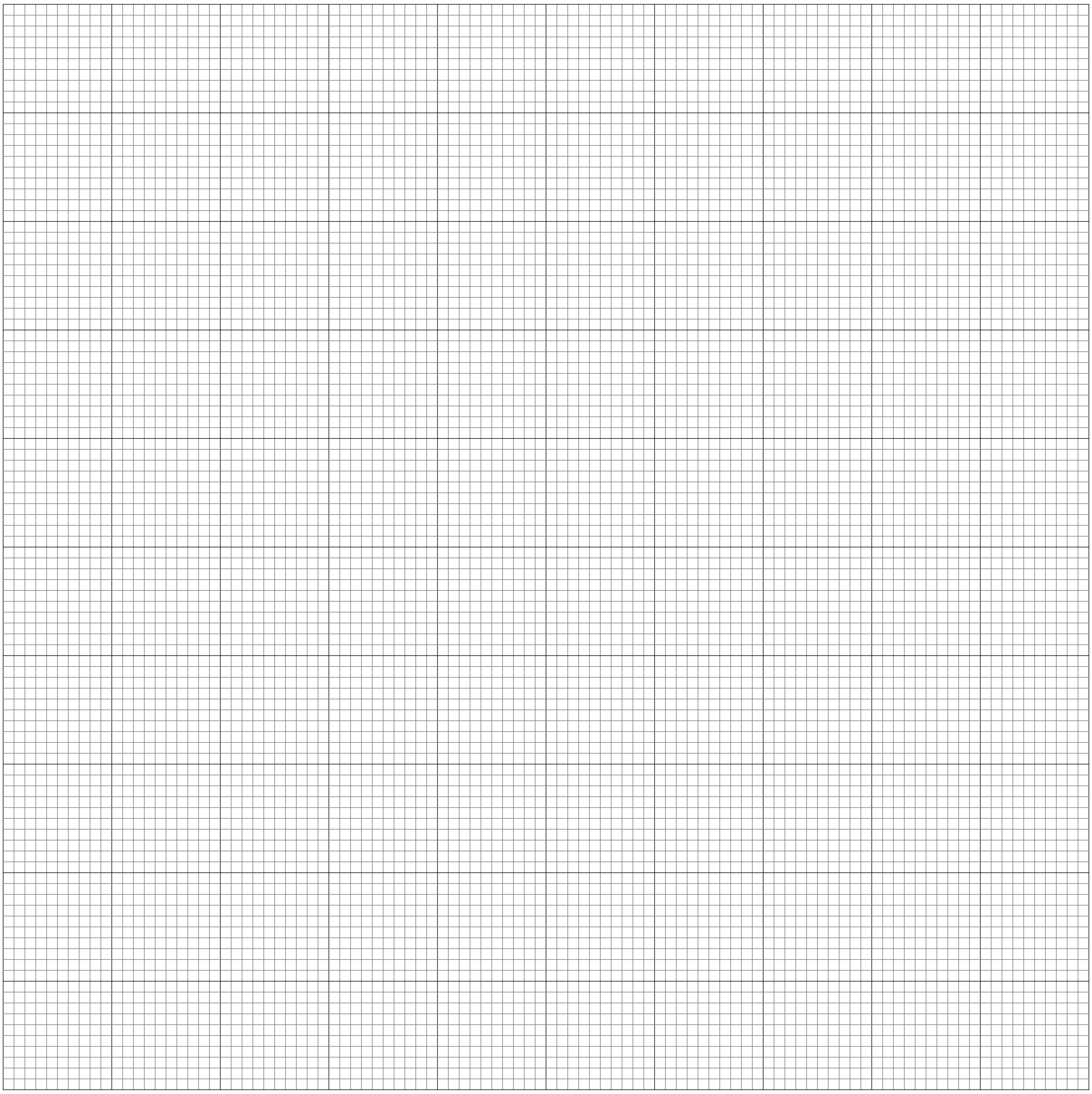

Fig. 8.1

(iii) Use your graph to calculate a value for n.

n = _______________ [3]

(iv) Use **Equation 8.1** to calculate a value for ρ, the density of air at the cruising height of this aircraft using the value of n obtained in **(iii)**.

ρ = _______________ kg m^{-3} [2]

Centre number

71	

Candidate number

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Physics

Assessment Unit A2 2

Fields and their Applications

SPECIMEN PAPER

TIME

1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in question 9.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.
Question 9 contributes to the synoptic assessment required of the specification.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

1 **(a)** **(i)** Explain what is meant by a **field of force**.

____

____

____ [2]

(ii) A field of force may be represented by a diagram showing a pattern of field lines.

1 Explain fully why the field lines in such a diagram can never cross.

____

____ [2]

2 Suggest how some information about the relative strength of a field can be obtained from the pattern of the field lines.

____ [1]

(b) Compare electric and gravitational fields, deducing one way in which the electric field strength near a point charge is **similar** to the gravitational field strength near a point mass and one way in which the force produced by an electric field is **different** from that produced by a gravitational field.

____

____

____

____ [2]

2 Newton's law of gravitation may be expressed by the equation:

$$F = \frac{Gm_1 m_2}{r^2}$$

(a) (i) Express Newton's law of gravitation in words.

____

____

____ [3]

(ii) Express the units of the constant G in terms of SI base units.

____

____

____ [1]

(b) The Earth may be assumed to be a uniform sphere. A uniform sphere behaves as if it were a point mass, with all its mass concentrated at the centre.

(i) Sketch the gravitational field pattern near the surface of the Earth on **Fig. 2.1** below.

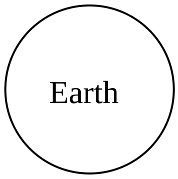

Fig. 2.1

[2]

(ii) Show how the acceleration of free fall g at the surface of the Earth is related to the mass M_E and radius R_E of the Earth.

____

____

____

g = ____________________ [2]

(iii) The radius of the Earth is 6.38×10^6 m. Use the relation you have derived in **(b)(ii)**, and information from your Data and Formulae Sheet, to calculate the density of the Earth.

Density = ___________________ kg m^{-3} [3]

3 **(a)** When two positive charges of magnitude Q_1 and Q_2 respectively are placed a distance r apart in a vacuum, they exert a force on each other.

(i) Write down the equation giving the magnitude F of the force the charges exert on each other. Identify any other symbols used.

____

____

____ [1]

(ii) By placing a tick in the appropriate box, indicate whether this force is attractive or repulsive.

Attractive ❑
Repulsive ❑

Explain your choice ______________________________ [2]

(b) **Fig 3.1** shows two point charges of magnitude ***+Q*** and ***+2Q*** respectively.

Fig 3.1

[3]

(i) Sketch the pattern of the electric field around and between the charges.

(ii) For this arrangement of charges, there is a point at which the electric field intensity is zero. On **Fig 3.1** mark with an **X** the approximate position of this point. [1]

(c) Two point charges of **A** and **B,** +*Q* and -2*Q* respectively, are placed in a vacuum.

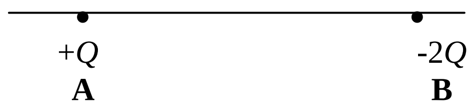

Fig. 3.2

P is the point at which the resultant electric field due to these two charges is zero.

(i) Explain why **P** cannot lie off a line joining the charges.

____

____

____ [2]

(ii) Deduce whether **P** can lie to the left of **A**, between **A** and **B** or to the right of **B**. Indicate your answer by placing a tick in the appropriate box.

P lies to the left of A ❑
P lies between A and B ❑
P lies to the right of B ❑

Explain your choice.

____

____

____ [3]

4 **(a) (i)** Define the farad, the unit of capacitance.

____

____

____ [1]

(ii) Discuss why this is an impractical unit to use for capacitance.

____

____

____ [1]

(b) **Fig 4.1** shows a charged capacitor connected in a circuit with a resistor and a switch.

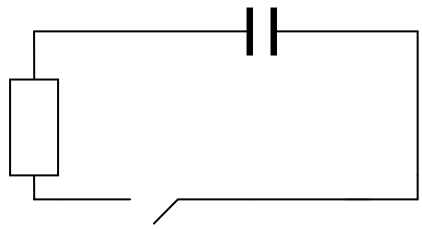

Fig 4.1

(i) What effect does the resistor have on the **discharge** of the capacitor?

____ [1]

(ii) Initially, before the switch is closed, the potential difference across the capacitor is V_0 and the charge on the plates is Q_0. At time $t = 0$, the switch is closed. On **Fig. 4.2**, sketch a graph showing the variation of charge Q with time t from the moment the switch is closed until the capacitor is effectively discharged. Label Q_0 on the curve. [3]

Fig. 4.2

(iii) What is the name given to the shape of this graph?

______________________________ [1]

(iv) Explain what is meant by the **time constant** of the circuit.

____

____

______________________________ [1]

(v) The capacitor in the circuit of **Fig. 4.1** has a capacitance 47 pF and the resistor has resistance 22 MΩ. How long after the switch is closed will it take for the potential difference across the capacitor to fall to 14% of its initial value?

Time = ______________ s [3]

5 **(a)** When a current is passed through a conductor, a magnetic field is created.

(i) **Fig. 5.1** illustrates a long straight wire carrying a current normally out of the plane of the paper.

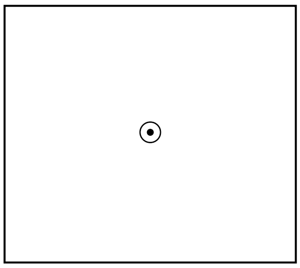

Fig. 5.1

On **Fig. 5.1** sketch the pattern of the magnetic field associated with this current-carrying conductor. [2]

The conductor carries a current of 5.0 A and is placed perpendicular to a uniform magnetic field. **Fig. 5.2** represents the uniform horizontal magnetic field. Remember the current is flowing out of the plane of the paper.

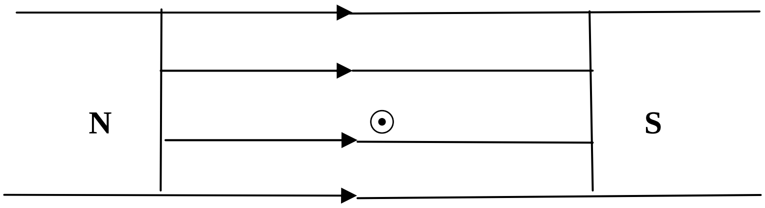

Fig. 5.2

(ii) In what direction is the force on the current-carrying conductor?

____ [1]

(b) The length of the wire in the field is 10 cm, and it experiences a force of magnitude 40 mN. Calculate the magnetic flux density of the field.

Magnetic Flux Density = ________________ T [3]

6 **(a)** Describe briefly the principle of operation of the transformer.

____

____

____

____

____

____ [3]

(b) A small factory receives power at 10.8 kV and this is converted to 240 V by a transformer. The factory draws 1200 A from the secondary coil. Calculate the primary current. Assume the transformer is 100% efficient.

Primary current = ____________________ A [3]

(c) In practice transformers are not 100% efficient. Name one source of power loss in a transformer.

____

____ [1]

7 **(a)** A cathode ray oscilloscope has its Y-amplifier sensitivity set at 5 Vcm^{-1}. The time base is switched off. The controls are adjusted so that the spot is at the centre of the screen.

Describe fully what would be seen on the screen when:

(i) a d.c. voltage of 6 V is applied to the input of the Y-amplifier,

____

____ [2]

(ii) an a.c. voltage of peak value 4 V is applied to the input of the Y-amplifier,

____

____ [2]

(b) With the Y-amplifier sensitivity still set at 5 V cm^{-1}, the timebase is now turned on and set at 25 μs cm^{-1}. A sinusoidal signal of frequency 10 kHz and peak voltage 12 V is then applied to the input of the Y-amplifier. **Fig. 7.1** illustrates the graticule on the screen, which is 10 cm across and 6 cm high.

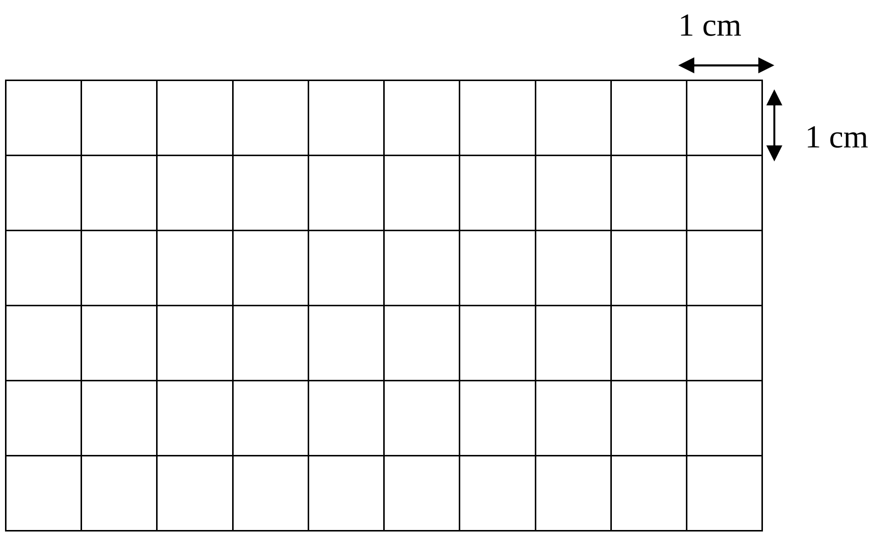

Fig. 7.1

(i) On **Fig. 7.1**, sketch the appearance of the waveform on the screen. [3]

(ii) Describe the adjustment which is required so that only one complete wave is displayed across the full width of the screen.

____

____

____ [2]

8 **(a)** There are two main groups of fundamental particles, called hadrons and leptons.

(i) Name one example of a lepton.

____ [1]

(ii) State one difference between hadrons and leptons.

____

____ [1]

(b) Hadrons can be classified as either baryons or mesons.

(i) In terms of quark structure, describe the structure of baryons and mesons.

Baryons: _______________________________________ [1]

Mesons: _______________________________________ [1]

(ii) Describe the structure of an atom in terms of the types of particles it contains and their constituent parts.

____

____

____ [3]

(c) Draw a labelled sketch of a linear accelerator and briefly describe the principle of operation.

____

____

____

____ [4]

9 Synoptic free-response question

This question contributes to the synoptic requirement of the Specification. In your answer, you will be expected to bring together and apply principles and contexts from different areas of physics, and to use the skills of physics, in the particular situation described.

In part (a) of this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

Communication Satellites

Geostationary satellites are widely used in telecommunications. They often receive their electrical power by the conversion of solar energy to electricity.

(a) A student makes the following statement about a geostationary satellite.

"(1) Because the satellite is geostationary, it has no kinetic energy. (2) However, work has been done to put it into orbit. (3) Therefore, its gravitational potential energy has been increased. (4) The magnitude of the change in potential energy is given by *mgh*, where *m* is the mass of the satellite, *g* is equal to 9.8 m s^{-2} and *h* is the distance between the Earth's surface and the satellite's orbit."

State which of the statements (1) to (4) is/are correct and which incorrect. If any part is incorrect, explain why.

____

____

____

____

____

____

____

____ [6]

Quality of written communication [2]

(b) A geostationary satellite is fixed with solar panels of area 40 m^2. The intensity of radiation from the Sun at the position of the satellite is 1.5 kW m^{-2} and the efficiency of the solar panels in converting light to electricity is 18%.

(i) Calculate the electrical power generated when the solar panels are placed perpendicular to the line from the Sun to the satellite.

Power = ________________ kW [2]

(ii) Assume that the radiation from the Sun can be treated as having a single wavelength of 550 nm,

(1) Calculate the energy of a photon of wavelength 550 nm.

Energy = ________________J [3]

(2) Calculate how many photons arrive on each square metre of the solar panels in one second. Assume that the radiation strikes them normally.

Number of photons per second = __________________ [2]

(iii) In part (ii) of this question you were told to make the assumption that sunlight can be treated as having a single wavelength. Give an example of an everyday observation that tells you that sunlight does not, in fact have a single wavelength.

____ [1]

Centre number

71	

Candidate number

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Physics

Assessment Unit A2 3

Practical Techniques (Internal Assessment)

SPECIMEN PAPER

TIME

1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

Answer **all** the questions in this paper, using this booklet. Rough work and calculations must also be done in this booklet. Except where instructed, do not describe the apparatus or the experimental procedures.

The Supervisor will tell you the order in which you are to answer the questions. Not more than 29 minutes are to be spent in answering each question. You may be told to start with the experimental tests in Section A, or with the single question in Section B.

Section A consists of two experimental tests. A 29-minute period is allocated to each of these tests. At the end of this period you will be instructed to move to the next test. At the end of the 29-minute period you will be instructed to move to the area set aside for your next question. Section B consists of one question in which you will be tested on aspects of planning and design.

You will be assessed on the quality of language demonstrated in your response to Question 3.

INFORMATION FOR CANDIDATES

The total mark for this paper is 60.
All questions carry 20 marks each.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each part question.
You may use an electronic calculator.

Section A

1 Introduction

In this experiment you are to measure the wall thickness of a glass test tube by an indirect method, which involves floating the test tube in water in a measuring cylinder.

Aims

The aims of the experiment are:

- to follow instructions in setting up the experiment and taking readings;
- to analyse the results using a graphical method;
- to determine a value for the wall thickness of the tube;
- to assess the uncertainty in this value.

Apparatus

You are provided with a measuring cylinder, which has already been filled with water to around the 70 ml mark, and a dry test tube. The test tube will be placed in the measuring cylinder, and small amounts of water added to it from the syringe provided, so that the tube floats as shown in **Fig. 1.1**.

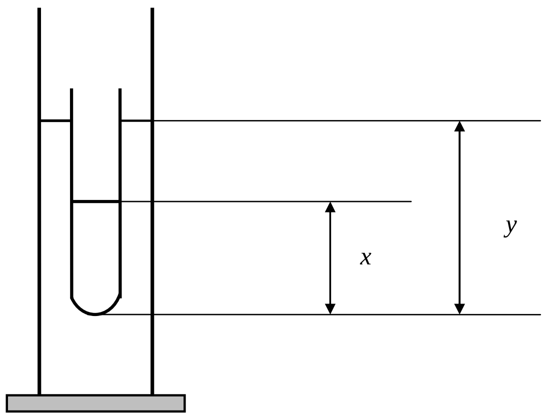

Fig. 1.1

In **Fig. 1.1**, x is the distance from the bottom of the tube to the water level in the test tube, and y is the distance from the bottom of the tube to the water level in the measuring cylinder. A rule is provided to measure these distances.

There is also a strip of graph paper to measure the circumference of the tube.

(a) Procedure

Use the strip of graph paper to measure the circumference *c* of the outer surface of the test tube. Record the value in part **(a)** of the **Results** section.

Lower the test tube carefully into the measuring cylinder so that it floats in the water. Using the syringe, add a few millilitres of water to the test tube and allow it to come to a new equilibrium position. Measure the distances *x* and *y* using a rule held close to the measuring cylinder. Record your results in **Table 1.1** of the Results section.

Add further quantities of water to the test tube to give a series of values of *x* and *y*, to cover as wide a range of *y* as possible. Record all your results in **Table 1.1**.

Results

Circumference of tube *c* = ___________ mm [2]

x/mm	
y/mm	

Table 1.1 [5]

Analysis

You are to plot a graph of *y* against *x*.

On the graph grid of **Fig. 1.2**, label the axes, choose suitable scales, plot the points and draw the best straight line through them. [5]

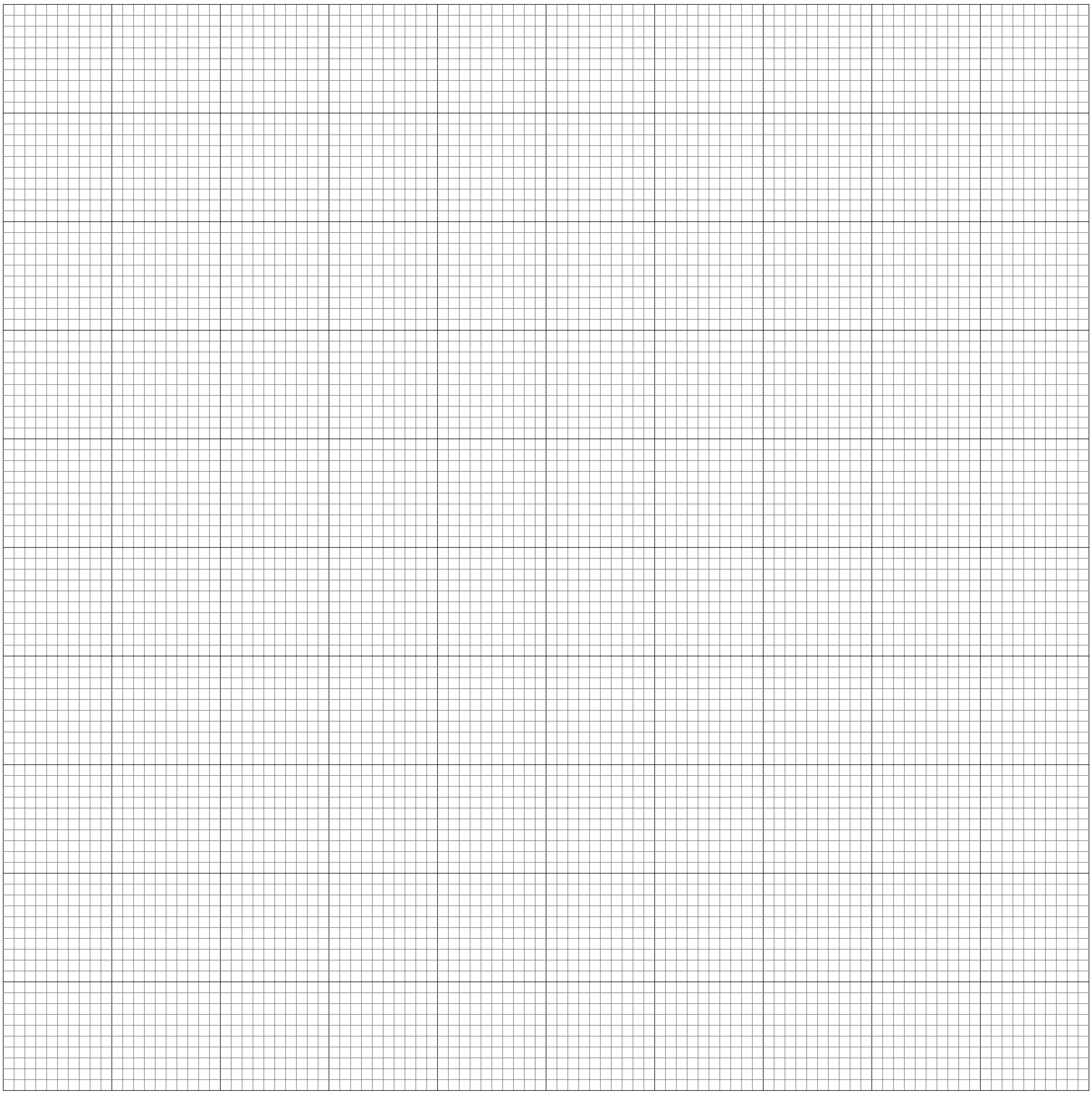

Fig. 1.2

(b) Measure the gradient *m* of your graph and enter the value below.

m = ____________________ [2]

(c) For a thin-walled tube, the wall thickness *t* is given approximately by

$t = \frac{c}{4\pi}(1 - m)$. **Equation 1.1**

Using your values of *c* and *m*, calculate the value of *t* and enter it below.

t = __________ mm [2]

Uncertainties

In arriving at your value of t there will be some uncertainty because of the uncertainty in the measurement of c and the uncertainty in obtaining m from the graph. Assume that the use of the assumption in **Equation 1.1** introduces a negligible additional error. Estimate the overall percentage uncertainty in your value of t. Show clearly how you arrive at this estimate.

Percentage uncertainty in t = ____________ % [4]

2 Introduction

In this experiment you will investigate how the current through a coil depends on the number of turns in the coil.

Aims

The aims of the experiment are:

- to construct a circuit to apply the same voltage across coils which have different numbers of turns;
- to measure the current through each coil;
- to analyse the experimental results to determine the cross-sectional area of the wire of which the coils are made.

Apparatus

You are provided with a power supply with an output of approximately 2 V, a variable resistor, an ammeter, a voltmeter, suitable connecting leads, and five coils. The coils have been wound around identical wooden rods, using wire of the same material and diameter. Each coil has a different number of turns, which is marked on a label on the rod.

Procedure

In the space below (**Fig. 2.1**), draw a diagram of a circuit, making use of the apparatus listed, which could be used to adjust the current through each coil in turn until a potential difference of 1.0 V is obtained across the coil. The current is also to be measured.

Fig. 2.1

If you have difficulty in designing this circuit, ask the Supervisor for assistance. You will be shown a card with the correct circuit diagram on it. A deduction of 3 marks will be made. [3]

Connect this circuit. Make contact to each end of the coil under investigation using a connecting lead with a crocodile clip attached to one end. Connect the crocodile clip to the wire at a point close to the wooden rod.

CAUTION: before switching on, ensure that the variable resistor is set to give the MAXIMUM resistance between its terminals.

If you have difficulty in connecting a working circuit, ask the Supervisor for assistance. A deduction of 2 marks will be made. [2]

For each coil, find the current *I* through the coil for the fixed potential difference of 1.0 V across the connections to the coil. The number of turns *N* in each coil is given on a label attached to the rod. Tabulate your results in **Table 2.1** in the **Results** section.

Results

N	25	20	15	10	8
I/*A*					
1/*N*	0.040	0.050	0.067	0.100	0.125

Table 2.1 [5]

Theory

Fig. 2.2 shows one of the coils.

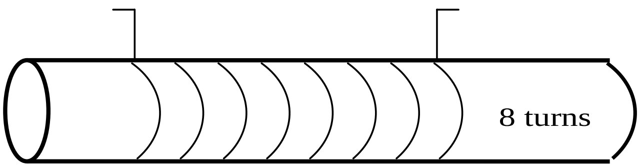

Fig. 2.2

The coil consists of *N* turns of wire wound on a rod of diameter *D*. Assume that the total length of wire between the points at which contact is made is πDN.

The current I in the coil is then given by:

$$I = \frac{VS}{(\rho \pi D N)}$$ **Equation 2.1**

where S is the cross-sectional area of the wire, ρ is the resistivity of the metal of the wire and V is the fixed potential difference of 1.0 V between the points of contact.

Analysis

You are to plot a graph of I against $1/N$.

(a) On the graph grid of **Fig. 2.3**, label the axes and choose suitable scales. Plot the points and draw the best straight line through them. [5]

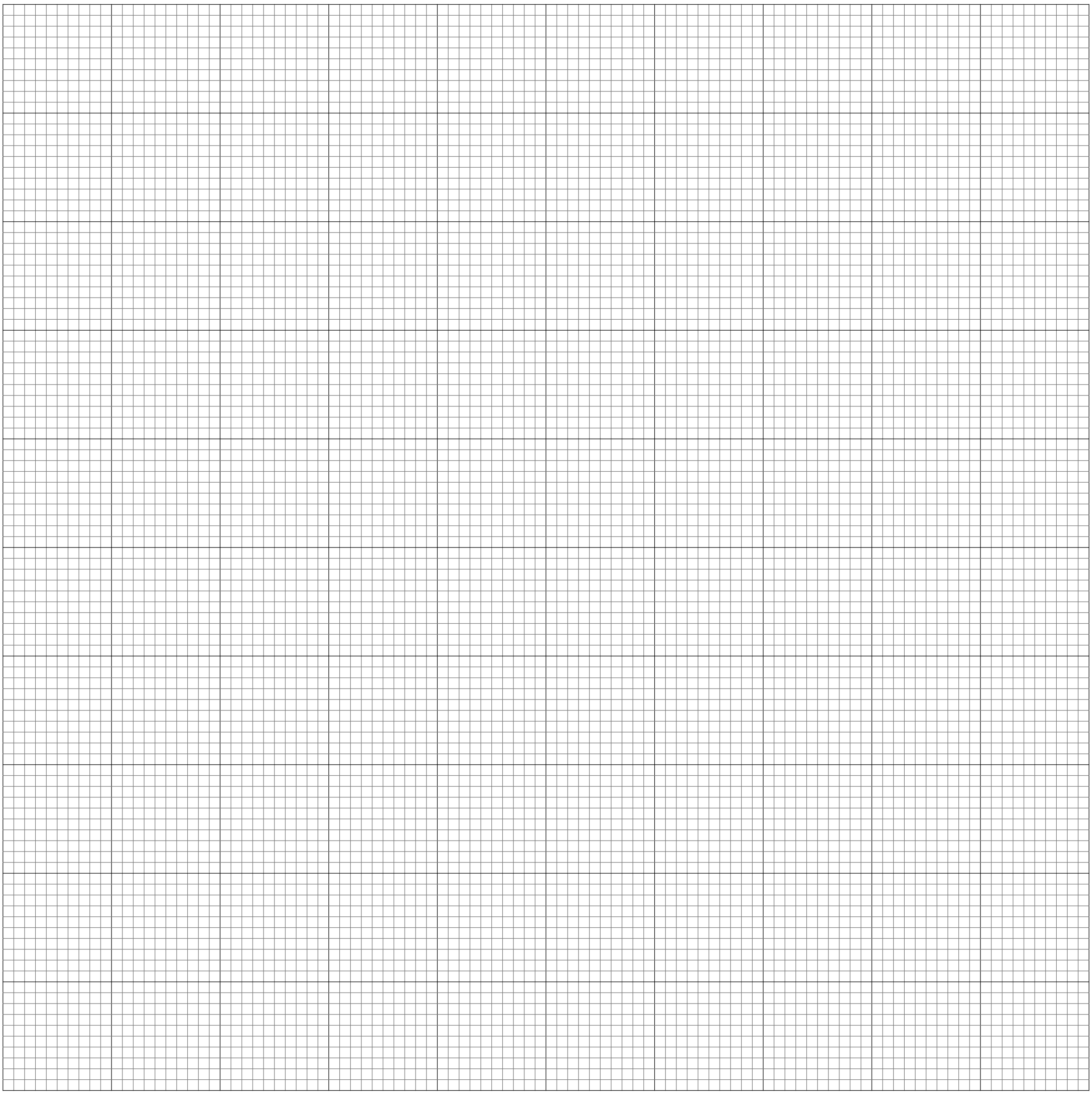

Fig. 2.3

(b) Measure the gradient of your graph and enter the value and unit below.

Gradient = ______________________________

Unit = ___________________________________ [3]

(c) The values of ρ and D are given on a card on the bench. Use these data, the value of the applied voltage V (1.0 V) and your value of the gradient to determine the cross-sectional area S of the wire of the coil.

S =____________ mm^2 [2]

Section B

3 **In part (a) of this question, you are expected to answer, where appropriate, in continuous prose. Marking will reflect the quality of written communication in this part of the question.**

Introduction

Fig. 3.1 illustrates an experiment to investigate water flow along a narrow tube.

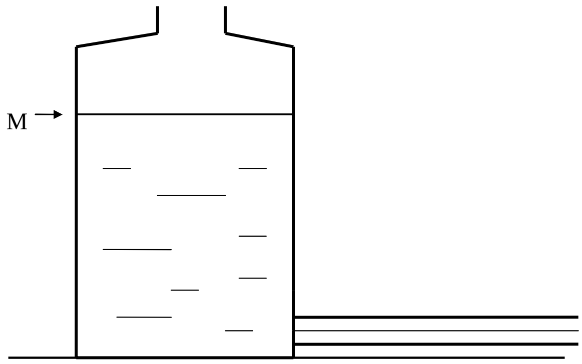

Fig. 3.1

A narrow glass tube (a capillary tube), of internal radius *r* and length *L*, is plugged into a large flask so that the tube is horizontal. Starting when the water level in the flask is at the mark M, the time *T* for a specified volume *V* to pass through the tube is determined.

It is thought that *T* is given by a relation of the form

$T = Ar^mLV$ **Equation 3.1**

where *m* is a constant, and *A* is also a constant provided that the experiment starts each time with the water level at the mark M.

A theory suggests that $m = -4$, but it is not certain that the conditions of the theory apply in this experiment.

Problems

You are asked to design an experiment to investigate the relation between *T* and *r* expressed by **Equation 3.1**.

Resources Available

You are provided with a number of capillary tubes of different, unknown, internal diameters in the range from about 1 mm to 4 mm but of the same length, a flask of the type illustrated in **Fig. 3.1**, and suitable rubber bungs. The normal equipment of your school or college Physics laboratory is also available.

Questions

(a) **(i)** Suggest how, for a given capillary tube, you would make an accurate measurement of T for the delivery of 100 ml of water.

[3]

(ii) Suggest a method for the measurement of r for a tube of internal diameter about 4 mm. Make a reasoned estimate of the likely percentage uncertainty in this measurement, appropriate to the method you choose.

[4]

(iii) In this experiment, it is important that the tubes used should have a reasonably constant internal diameter along their length. Suppose that a thread of liquid about 20 mm long has been introduced into a capillary tube of internal diameter about 1 mm. Suggest a method of checking the constancy of the internal diameter of the tube.

[2]

Quality of written communication [2]

(b) Assume that a set of values of T and r has been obtained.

(i) State how you would use a graphical method to obtain a value for the constant m in **Equation 3.1**. State also the equation on which your graph is based.

____

____

____

____ [3]

(ii) State how a value for the constant A could be obtained from the graph in **(b)(i)**.

____

____

____ [2]

(c) Suggest two safety precautions that should be adopted in this experiment.

1 ____

2 ____ [2]

(d) Suppose that the results of the graphical analysis in **(b)** showed that the value of m in **Equation 3.1** was –4, as predicted by theory.

On **Fig. 3.2**, sketch a graph of the way in which T would vary with r. [2]

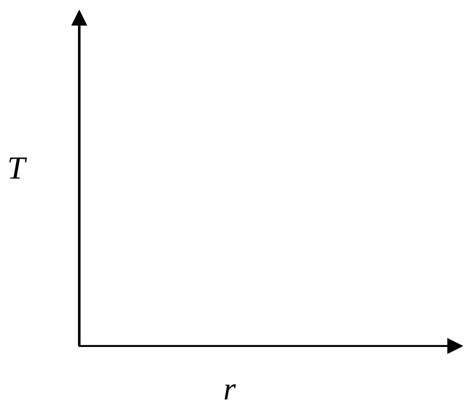

Fig. 3.2

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Physics

Assessment Unit A2 3

Practical Techniques (Internal Assessment)

CONFIDENTIAL INSTRUCTIONS FOR A2 3 PRACTICAL TEST

Question 1

Requirements

1 Test tube, 150 mm × 18 mm (one for each candidate).
2 Measuring cylinder, 100 ml × 1.0 ml.
3 Beaker, 250 ml.
4 Syringe.
5 Stand, clamp and boss.
6 Metre rule.
7 Graph paper.

Preparation

Clamp the measuring cylinder vertically, using the stand, clamp and boss. Place it at a convenient place on the bench.

Add water to the cylinder to the 70 ml mark. Add about 200 ml of water to the beaker, and leave beside the measuring cylinder. Fill the syringe with water to the 5 ml mark, ensuring that air is excluded.

Cut a strip of graph paper 150 mm × 20 mm for each candidate.

Before the Examination

Place the test tube, syringe, beaker of water, metre rule and strip of graph paper near the clamped measuring cylinder.

Action at changeover

Remove the test tube from the measuring cylinder and top up the water level in the cylinder to the 70 ml mark. Refill the syringe to the 5 ml mark. Remove the strip of graph paper.

Place a dry test tube and a new strip of graph paper on the bench near the measuring cylinder, metre rule and beaker.

Question 2

Requirements

1 D.c. power supply, capable of providing approximately 2.0 V.
2 Ammeter, 0 – 2 A d.c., analogue or digital.
3 Voltmeter, 0 – 2 V d.c., analogue or digital.
4 Constantan (Eureka) wire, s.w.g. 30.
5 Wooden dowel, 13 mm diameter, 0.5 m length.
6 Rheostat.
7 Connecting leads.
8 Self-adhesive labels.
9 Insulating tape.

Preparation

Cut five 100 mm lengths of the dowel.

Take one length of dowel and tightly wrap eight turns of constantan wire around it, taking care not to let neighbouring turns touch. Secure the turns in place with insulating tape. Bend the ends of the wire at right angles to the dowel and cut off surplus wire, leaving only about 5 mm projecting from the curved surface of the dowel. Write "**8 turns**" on a small self-adhesive label and attach it to the dowel. The arrangement is illustrated in **Fig. 2.2**.

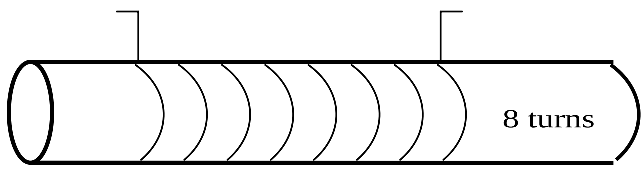

Fig. 2.2 Coil on dowel

On the remaining four lengths of dowel, wrap coils of ten, fifteen, twenty and twenty-five turns respectively. Secure the turns and cut off surplus wire as before. Prepare labels with the information "**10 turns**", "**15 turns**", "**20 turns**" and "**25 turns**", and attach them to the corresponding dowels.

Set the output of the power supply to approximately 2.0 V. Tape the output control so that the candidate cannot adjust it.

It will be required to use two terminals on the rheostat: that at the end of the slider bar, and that at the opposite end of the rheostat coil. Tape over or remove the terminal at the nearer end of the rheostat coil so that the candidate cannot use it.

On a card, provide the circuit diagram of **Fig. 2.1**.

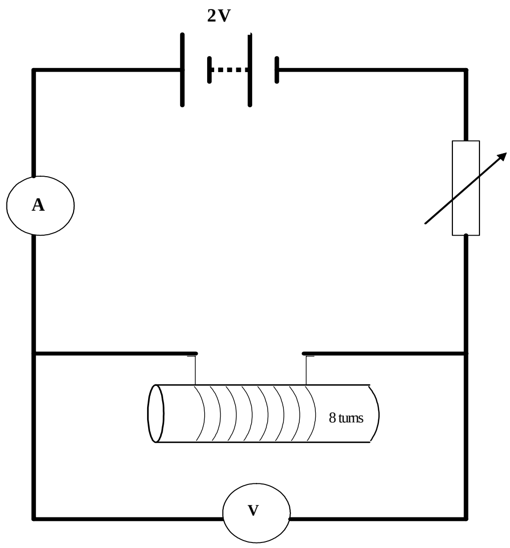

Fig 2.1 Circuit diagram

The card must be placed out of view of the candidates, but should be made available to any candidate requesting assistance with the **design** of the circuit. **If the candidate is given this assistance, award 0 marks in this part of the script.**

Measure the diameter *D* of the dowel, to the nearest tenth of a mm. Prepare a card with the following information:

$$\boldsymbol{D} = \mathbf{13.1\ mm}\ \text{(eg)}$$
$$\boldsymbol{\rho} = \mathbf{4.90 \times 10^{-7}\ \Omega\ m}$$

Two of the six connecting leads must have 4 mm plugs at one end and 4 mm plugs connected to crocodile clips at the other, to make contact with the protruding ends of the wire coils. If the meter terminals are not provided with 4 mm sockets, the relevant connecting leads should have spade terminals.

Testing

Connect the circuit shown in **Fig. 2.1**, using the 8-turn coil. Use the rheostat to adjust the potential difference across the coil to 1.0 V. Check that the current is about 0.6 A.

Before the Examination

Place the power supply, ammeter, voltmeter, rheostat set to maximum resistance, connecting leads and five coils **unconnected** on the bench.

Leave the card with the dowel diameter and wire resistivity data on the bench.

During the Examination

If the candidate requests assistance with the **design** of the circuit, show the circuit diagram card and mark the candidate's script with a score of 0 for this part.

If the candidate requests assistance with the connection of the circuit, first check the candidate's circuit diagram. If this is **correct**, connect the circuit and carry out the **Testing** procedure above. Mark the candidate's script with a score of 0 for this part.
If the candidate's circuit diagram has to be corrected, show the circuit diagram card (with a score of 0 for this part) and allow the candidate another attempt at connection without penalty.

Action at changeover

Disconnect the apparatus and leave as at the start of the examination.

Mark Schemes

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General Certificate of Education
2009

Physics

Assessment Unit AS 1

Forces, Energy and Electricity

SPECIMEN PAPER

MARK SCHEME

1	**(a)**	**(i)**	Scalars have no direction, vectors do	[1]	
		(ii)	Energy, distance, mass, speed ½ each, round down	[2]	
	(b)	**(i)**	Max force = 28 N	[1]	
			Max a = 5.6 m s^{-2}	[1]	
			Min F = 4 N	[1]	
			Min a = 0.8 m s^{-2}	[1]	
		(ii)	$R^2 = 12^2 + 16^2$	[1]	
			R = 20 N	[1]	
			tan θ = 12/16 θ = 37°	[1]	[10]
2	**(a)**	A:	steady speed 8 m s^{-1}	[1]	
		B:	constant acceleration until 8 s, then steady speed	[2]	
		C:	non-uniform acceleration	[1]	
	(b)	**(i)**	dist = area under graph	[1]	
			dist = (½ × 8 × 14) + (4 × 14)	[1]	
			dist = 112 m	[1]	
		(ii)	draw tangent or shown on graph	[1]	
			Calculate gradient of tangent	[1]	
	(c)	**(i)**	4.5 s	[1]	
		(ii)	Before this, A travelling faster than B So distance between them increases After that point, B travelling faster than A So starts to reduce distance between them or catch up		
			Any 3 points	[3]	[13]
3	**(a)**		ACM = CM	[1]	
			If in equilibrium	[1]	
	(b)	**(i)**	Arrow up in spring	[1]	
		(ii)	Total force = 735.8 N	[1]	
			Force per lever = 183.9 N	[1]	
		(iii)	184 × 3 = F × 20	[1]	
			28 (27.6) N (ecf from (ii))	[1]	

(iv) $F = kx$

$28 = k\ (6 \times 10^{-3})$ (ecf from (iii)) [1]

4600 N m^{-1} [2]

(c) Make distance to spring longer

Use spring with higher spring constant

Use more than 4 levers inside scales [1] [11]

4 **(a)** Ultimate tensile strength [1]

(b) **(i)** Suitable scale [1]

Points correct [1]

Line drawn [1]

(ii) Limit of proportionality between 3-3.3 × 10^{-4}(m) [1]

(iii) Stress = F/A [1]

$= \dfrac{5 \times 10^{-3}}{2.38 \times 10^{-5}}$ [1]

= 210 (N m^{-2}) [1]

(iv) strain = $\dfrac{x}{L}$ [1]

$= \dfrac{2.6 \times 10^{-4}}{0.25}$ [1]

$= 1.04 \times 10^{-5}$ [1]

(v) $E = \dfrac{\text{Stress}}{\text{Strain}}$ [1]

$E = \dfrac{210}{1.04 \times 10^{-5}}$ ecf from **(iii)** [1]

$E = 2.02 \times 10^{3}$ Pa [1] [14]

5	**(a)**		Energy can be changed from one form to another but cannot be created or destroyed	[1]	
	(b)		$W = 540 \times 1.8$	[1]	
			$W = 972$ J	[1]	
	(c)	**(i)**	p.e. at start = k.e. at end	[1]	
			$9.81 \times 3.7 = \frac{1}{2} v^2$	[1]	
			$v = 8.5$ ms^{-1}	[1]	
		(ii)	Slower	[1]	
			Idea of energy 'loss' eg friction between hands & bar	[1]	[8]
6	**(a)**	**(i)**	Correct symbol for thermistor	[1]	
			Ammeter in series	[1]	
			Voltmeter across thermistor	[1]	
		(ii)	Variable resistor or variable power pack	[1]	
	(b)	**(i)**	*V*at 0.3 mA = 9 – 9.4 V	[1]	
			Subs $R = 9.2/0.3 \times 10^{-3}$	[1]	
			$R = 30.7$ kΩ (30 – 31.3 kΩ)	[1]	
		(ii)	*R* increases	[1]	
			As current increases, temperature increases	[1]	
			Idea of impeding electron flow from increased vibration of atoms	[1]	[10]

7	Graph: *R* decreasing with decreasing *T* above transition temp		[1]
	Abrupt, vertical change to $R = 0$ at transition temp		[1]
	Transition temp – temp below which material becomes superconducting		[1]
	No electrical resistance		[1]
	No resistance means no energy/heat/power loss in wires		[1]
	Less fuel needed		[1]
	Other uses: eg Superconducting magnets, Scanners for MRI, magnetic levitation, monorail trains, particle accelerators …	Any 2	[1]

Max 7 points, 1 each

Quality of Written Communication

2 marks

The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

1 mark

The candidate expresses ideas clearly, if not always fluently. Arguments may sometimes stray from the point. There are some errors in grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.

0 marks

The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2] [9]

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Physics

Assessment Unit AS 2

Waves, Photons and Medical Physics

SPECIMEN PAPER

MARK SCHEME

1	**(a)**	**(i)**	6 (mm)	[1]	
		(ii)	0.6 (ms)	[1]	
		(iii)	f = 1666.6 Hz ecf from (a)(ii)	[1]	
			$v = \lambda f$	[1]	
			$v = 6.2 \times 10^{-2} \times 1666.6$	[1]	
			v = 103 (m s^{-1})	[1]	
	(b)		Transverse: any em wave, water wave	[1]	
			Longitudinal wave: sound, p-type earthquake waves	[1]	[8]

2	1	MRI	= magnetic resonance imaging		
		CT	= computed tomography	[1]	
	2	MRI	nuclei are excited when they absorb radio waves	[1]	
			relaxing nuclei emit em radiation and this is used to form the image.	[1]	
		CT	X-rays are repeatedly passed through the body at different angles and detected	[1]	
			image is built up over time	[1]	
	3	MRI	very strong magnetic field; heating effects, ferromagnetic projectiles	[1]	
		CT	large dose of ionising radiation	[1]	

Quality of Written Communication

2 marks

The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

1 mark

The candidate expresses ideas clearly, if not always fluently. Arguments may sometimes stray from the point. There are some errors in grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.

0 marks

The candidate expresses ideas satisfactorily, but without precision.
Arguments may be of doubtful relevance or obscurely presented.
Errors in grammar, punctuation and spelling, are sufficiently intrusive to disrupt the understanding of the passage. [2] [9]

3	**(a)**	**(i)**	Ray through pole; not deviated	[1]	
			Ray parallel to PA; from F_1	[1]	
			Ray to F_2; parallel to PA	[1]	
		(ii)	Correct image	[1]	
	(b)	**(i)**	$\frac{1}{f} = \frac{1}{0.25} - \frac{1}{1.6}$	[1]	
			$\frac{1}{f} = 3.375$	[1]	
			$f = 0.30$ (m)	[1]	
		(ii)	3.38 ecf from (b)(i)	[1]	
			D or dioptres or m^{-1}	[1]	[9]

4	**(a)**	Region of hearing	[1]	
	(b)	$I_1 = 1 – 100$ (Wm^{-2})	[1]	
		$f_1 = 10 – 30$ (Hz)	[1]	
		$f_2 = 1500 – 3000$ (Hz)	[1]	
		$f_3 = 18000 – 22000$ (Hz)	[1]	
	(c)	IL = 10 log $(5 \times 10^{-9}/10^{-12})$	[1]	
		IL = 37	[1]	
		dB	[1]	[8]

5	**(a)**	Labelled sketch indicates:	water trough	[1]
			Resonance tube in trough	[1]
			Rule in correct position	[1]
			Tuning fork(s) in correct position	[1]
	(b)	**(i)**	Correct sketch	[1]
		(ii)	Correct labelling of (all) nodes	[1]
			Correct labelling of (all) antinodes	[1]
		(iii)	Position of minimum (zero) displacement	[1]

	(c)	$\lambda = 4L$	[1]	
		$\lambda = 2.64$ (m)	[1]	
	(d)	Grad = 357/4.2	[1]	
		Grad = 85	[1]	
		Gradient = $v/4$	[1]	
		$v = (85 \times 4) = 340$ (m s^{-1})	[1]	[14]
6	**(a)**	**(i)** Constant phase relationship	[1]	
		(ii) Similar (or same) amplitude.	[1]	
	(b)	A regions ticked	[1]	
		Path difference = 0 at midline position	[1]	
		Crest meets trough due to 180° phase difference.	[1]	
	(c)	$550 \times 10^{-9} = (0.2 \times 10^{-3}\, y)/4$ Subs	[2]	
		$y = 0.011$ (m)	[1]	
		$y = 11$ (mm)	[1]	[9]
7	**(a)**	Photons	[1]	
		have insufficient energy	[1]	
		photon energy $\propto$ frequency	[1]	
	(b)	**(i)** $E = hf$	[1]	
		$6.9 \times 10^{-19} = 6.63 \times 10^{-34} \times f$	[1]	
		$f = 1.0 \times 10^{15}$ (Hz)	[1]	
		(ii) $\lambda = 3.0 \times 10^{8}/1.0 \times 10^{15} = 3.0 \times 10^{-7}$ (m)	[1]	
		(iii) Transferred energy = 11.4×10^{-19} (J)	[1]	[8]
8	**(a)**	Circular wavefronts on LH diagram	[1]	
		Wavefronts correctly bent at edges on RH diagram	[1]	
		No wavelength variation [1] each diagram	[2]	
	(b)	Molecular spacing in A is shorter or closer or smaller etc	[1]	
		Micrograph ring pattern is more spread out or fewer rings	[1]	
		which means a greater amount of diffraction has occurred	[1]	
	(c)	$0.54 \times 10^{-9} = 6.63 \times 10^{-34}$/momentum (subs)	[1]	
		v = momentum/electron mass	[1]	
		$v = 1.3 \times 10^{6}$ (ms^{-1})	[1]	[10]

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Physics

Assessment Unit AS 3

Practical Techniques (Internal Assessment)

SPECIMEN PAPER

MARK SCHEME

Section A

1	**(a)**	**(i)** Diameter estimate **in range 60 mm – 70 mm**	[1]	
		(ii) Top of can not same diameter as body		
		or		
		Mention of parallax	[1]	
	(b)	Measurement of length L of string for more than one turn	[1]	
		Use of $L = 2\pi rn$	[1]	
		Diameter **in range 66 mm to 70 mm**	[1]	[5]
2	**(a)**	Time t for at least 10 oscillations	[1]	
		One or more repeats of t	[1]	
		T **in range 0.70 s to 0.75 s**	[1]	
	(b)	L_{min} **in range 120 mm to 130 mm**	[1]	
		Oscillations become too rapid to count *or* decay too rapidly	[1]	[5]
3	**(a)**	**(i)** v **in range 580 mm to 620 mm**	[1]	
		(ii) **± 5 mm or more**	[1]	
		Difficulty of telling exact focus point/finding sharp image	[1]	
	(b)	Correct subs	[1]	
		f **in range 148 mm to 152 mm**	[1]	[5]
4	**(a)**	Sets up circuit without help	[1]	
	(b)	**(i) & (ii)** Three sets of values of V and R at [1] each	[3]	
	(c)	R_{av} **in range 4.5 Ω to 4.9 Ω**	[1]	[5]

Section B

5 **(a)** **(i)** Horizontal: **1/*R*** [1]
Vertical: **1/*V*** [1]

(ii) **Gradient = *r*/*E*** [1]
Intercept = 1/*E* [1]

(b) **(i)** Headings **(1/*R*)/Ω^{-1}** [1]
(1/*V*)/V^{-1} [1]

(ii)

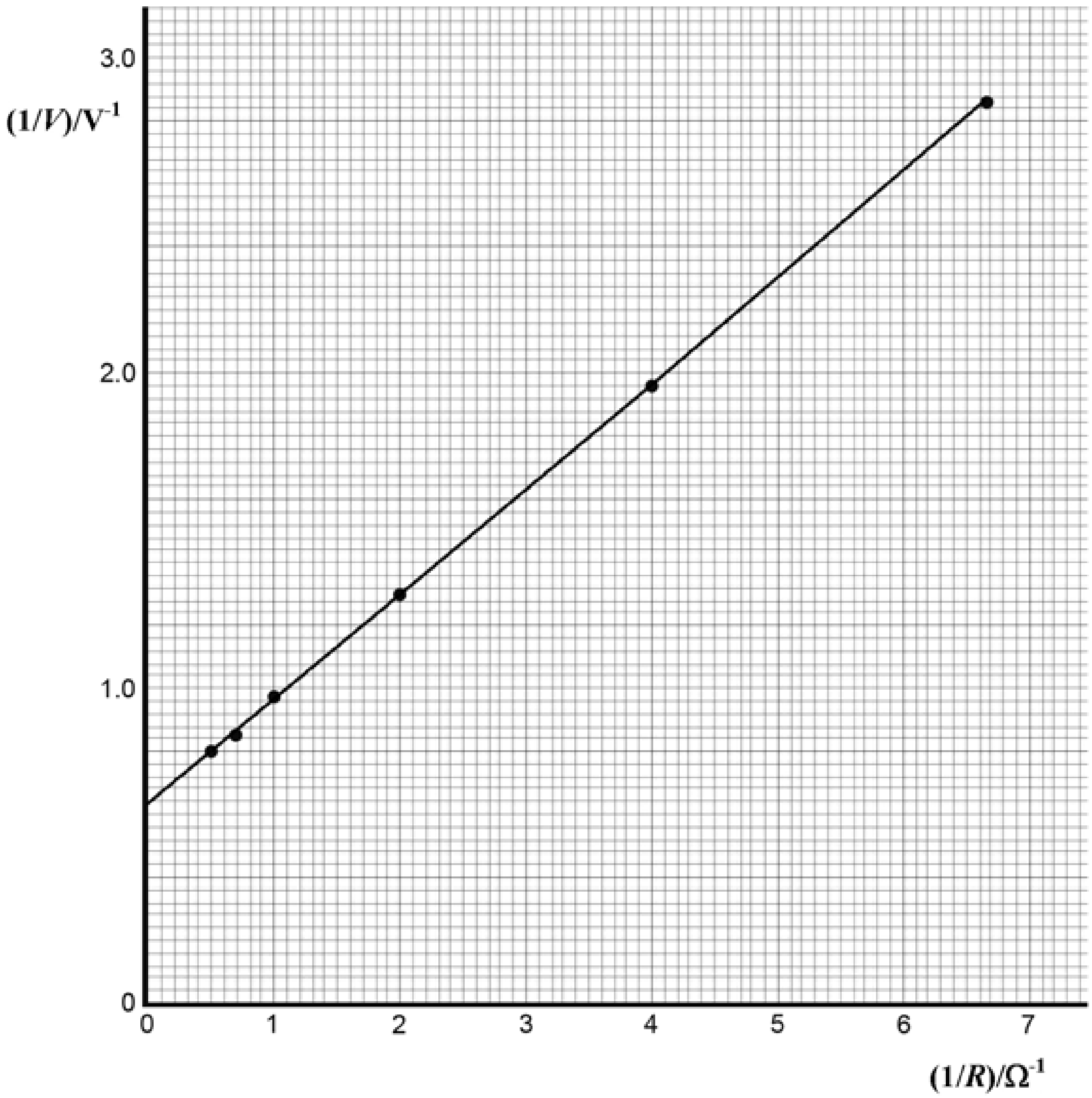
R/Ω	*V*/V	*x*-axis	*y*-axis
0.15	0.35	**6.67**	**2.86**
0.25	0.51	**4.00**	**1.96**
0.50	0.77	**2.00**	**1.30**
1.00	1.03	**1.00**	**0.97**
1.50	1.17	**0.67**	**0.85**
2.00	1.25	**0.50**	**0.80**

(not to 2 d.p., -1)

Table 5.1

Each column [1]
[1]

(iii) Axis labels (units not needed, as rewarded in **(b)(i)**) [1]
Scales (at least half available axis, no awkward factors) [1]
Six points plotted (-1 each error) [1]
Best straight line [1]



(c)	**(i)**	Gradient: student's value from correct read-offs Unit: Ω V^{-1} *or* A^{-1}	[1] [1]
	(ii)	Intercept: student's value from correct read-off Unit: V^{-1}	[1] [1]
	(iii)	***E*** **in range 1.55 V to 1.60 V** ***r*** **in range 0.50 Ω to 0.55 Ω**	[1] [1]
(d)	**(i)**	So as not to take current from circuit	[1]
	(ii)	Too few points at high 1/*V*, 1/*R* *or* at low *V*, *R*	[1] [20]

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Physics

Assessment Unit A2 1

Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

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MARK SCHEME

1	**(a)**	Total momentum constant or total momentum before = total momentum after		[1]	
		No forces act/isolated system		[1]	
	(b)	**(i)**	$p = mv$		
			$36 \times 10^3 = 1200 \times v$	[1]	
			Velocity before = 30 m s^{-1}	[1]	
		(ii)	Velocity after = 20 m s^{-1}	[1]	
		(iii)	Momentum before = Momentum After	[1]	
			$36000 + (-250)(20) = 24000 + 250\,v$	[1]	
			$v = 28$ m s^{-1}	[1]	
			Same direction as car was moving/opposite direction to way initially moving	[1]	
		(iv)	Inelastic	[1]	
			Kinetic energy before > ke after	[1]	
			Total ke before = 590000J or Total ke after = 338000 J	[1]	[12]

2	**(a)**	Pressure increases		[1]	
		(when *T* increases) speed of molecules increases	Any 3 out of these 4	[1]	
		More collisions per second with walls		[1]	
		Greater change in momentum		[1]	
		Greater *F*, (therefore increased pressure)			
	(b)	**(i)**	$pV=nRT$	[1]	
			T conversion to 288 K	[1]	
			$1.04 \times 10^5 (1.36 \times 10^{-3}) = n(8.3)(288)$ Subs	[1]	
			$n = 0.059$	[1]	
			$N = N_A (0.059)$		
			$N = 3.55 \times 10^{22}$	[1]	
		(ii)	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	[1]	
			$\frac{1.04\times10^5}{288} = \frac{P_2}{298}$	[1]	
			$P_2 = 1.08 \times 10^5$ (Pa)	[1]	
		(iii)	ke increase = $\frac{3}{2}\, k \times 10$	[1]	
			increase in ke each molecule = 2.07×10^{-22} (J)	[1]	
			all molecules = $3.55 \times 10^{22} \times (2.07 \times 10^{-22}) = 7.35$ (J) or ecf from **(a)**	[1]	[15]

3	**(a)**	Acceleration is directly proportional to displacement from fixed point		[1]	
		Always directed towards that point		[1]	
	(b)	**(i)**	$\omega = 2\pi f$ $= \dfrac{2\pi}{0.16 \times 10^{-3}}$ } either	[1]	
			$= 39000$ rad s^{-1}	[1]	
		(ii)	$a = -\omega^2 x$	[1]	
			$a = -\omega^2(0.6 \times 10^{-3})$	[1]	
			$a = 913000$ m s^{-2}	[1]	
	(c)	period correct		[1]	
		π/2 rad ahead		[1]	
		smooth curve		[1]	[10]

4	**(a)**	**(i)**	States $v = r\omega$ & v constant or $r \propto \dfrac{1}{\omega}$	[1]	
			Angular velocity decreases as r increases	[1]	
		(ii)	$\omega = 91.7$ rad s^{-1}	[1]	
			$r = \dfrac{3.84}{91.7}$	[1]	
			$r = 4.2$ (cm)	[1]	
	(b)	States equation $F = \dfrac{mv^2}{r}$ or $F \propto v^2$		[1]	
		Higher v of DVD - larger centripetal force needed (or lower v of CD...)		[1]	
		Friction provides centripetal force		[1]	
		Dust particles more likely to stick on CD		[1]	[9]

5 **(a)** Observations:

most α particles passed straight through:
A few deflected through small angles
Some scattered back through very large angles – toward the source

Conclusions:

Nucleus is positively charged
Most of atom is empty space
Nucleus concentrated at centre

2 observations, 2 conclusions – 1 each [4]

(b) **(i)** Correct subs of any *A* and *r* [1]
$r_0 = 1.3 \times 10^{-15}$ m [1]

(ii) *y*-axis: *r* or log (ln) [1]
x-axis: $A^{1/3}$ or log (ln) [1]

(iii) If $r - A^{1/3}$ then gradient = r_0
If log, then gradient = 1/3 [1]

(iv) If $r - A^{1/3}$ then intercept = 0
If log, then intercept = log r_0 [1] [10]

6 **(a)** Range is only a few cm in air (or equivalent) [1]

(b) electron removed from air particles [1]
creates ions [1]
Double positive charge [1]

(c) Rate of decay/Number of decays per second [1]

(d) $\lambda = \dfrac{0.693}{432}$ [1]

$\lambda = 1.6 \times 10^{-3}\ \text{yr}^{-1}$ [1]

use of $A = A_o e^{-\lambda t}$ [1]

A = 33.4 kBq (or ecf from (i)) [1] [9]

7 **(a)** Fission – splitting of heavy nucleus into lighter nuclei
Fusion – 2 lighter nuclei fusing to form heavier nucleus
Both processes release energy
Nuclei to left of peak undergo fusion to increase stability/reach higher BE per nucleon
Nuclei to right undergo fission to increase stability/reach higher BE per nucleon
Higher binding energy per nucleon= greater stability
Increase in binding energy **per nucleon** is greater for light nuclei undergoing fusion
Heavier nuclei have more nucleons so total binding energy much larger.
Overall reduction in binding energy larger in fission of a heavy nucleus than in fusion of 2 light nuclei

Any 6 (1 each) [6]

Quality of Written Communication

2 marks

The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

1 mark

The candidate expresses ideas clearly, if not always fluently. Arguments may sometimes stray from the point. There are some errors in grammar, punctuation and spelling, but not such as to suggest a weakness in these areas.

0 marks

The candidate expresses ideas satisfactorily, but without precision. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling are sufficiently intrusive to disrupt the understanding of the passage. [2]

(b) Need very high temperature [1]
Need to confine nuclei for a long time [1] [10]

8	**(a)** More accurate at high velocities	[1]	
	If velocity is low, difference in pressures won't be large enough	[1]	
	Difference needs to be larger than error in instrument	[1]	
	or similar argument		
	(b) (i) Correct values calculated for log *v*	[1]	
	Correct values calculated for log *q*	[1]	
	Inconsistent significant figures in either or both columns -1		
	(ii) log *q* on *y*-axis, log *v* on *x*-axis and labelled	[1]	
	Suitable scale	[1]	
	Points correctly plotted	[2]	
	Best fit line	[1]	
	(iii) Large triangle	[1]	
	Correct values from graph in $\frac{\Delta y}{\Delta x}$	[1]	
	Candidates values of *n* approx 2	[1]	
	(iv) Subs into equation with value of *n*	[1]	
	ρ = approx 0.90	[1]	[15]

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Physics

Assessment Unit A2 2

Fields and their Applications

SPECIMEN PAPER

MARK SCHEME

1 **(a)** **(i)** Region where force is exerted [1]
on test charge/mass [1]

(ii) 1 Field lines show direction of motion of test charge/mass [1]
Crossing lines indicate non-unique field direction [1]

2 Strength of field from closeness of lines [1]

(b) both obey inverse square law [1]

force in electric field can be attractive or repulsive
(or force in gravitational field is always attractive) [1] [7]

2 **(a)** **(i)** The attractive force between two point masses [1]
is proportional to the product of the masses [1]
and inversely proportional to the square of their distance apart. [1]

(ii) $m^3\ kg^{-1}\ s^{-2}$ [1]

(b) **(i)** radial lines [1]
inwards arrows [1]

(ii) $mg = GmM_E/R_e^2$ [1]
$g = GM_E/R_e^2$ [1]

(iii) $M_E = 4/3\ \pi R_E^3\rho$ density eq [1]
$\rho = 3g/4\pi GR_E$ combines g and density eq [1]
$= (3 \times 9.81)/(4\pi \times 6.67 \times 10^{-11} \times 6.38 \times 10^{6})$ subs or ans [1] [11]
$(= 5.5 \times 10^3\ (kg\ m^{-3}))$

3
(a) **(i)** $F = \dfrac{1}{4\pi\varepsilon_o}\dfrac{Q_1Q_2}{r^2}$ [1]

(ii) Repulsive marked [1]
Explanation – both positive charges – like charges repel [1]

(b) **(i)** radial with arrows outwards [1]
except between [1]
more lines from 2*Q* than *Q* [1]

(ii) On line of charges, between *Q* and 2*Q*, nearer to *Q* [1]

(c) (i) Forces due to A and B must be in same straight line [1]
If not their resultant could not be zero [1]

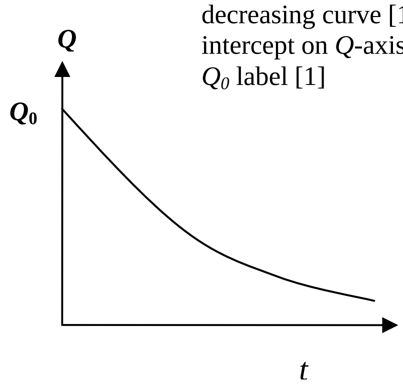
(ii) P to the left of A [1]
Positive charge repelled by A [1]
B further away but charge greater [1] [12]

4 **(a)** **(i)** 1 farad is the capacitance of a capacitor with charge of 1 coulomb and potential difference of 1 volt between the plates
(or 1 farad = 1 coulomb per volt) [1]

(ii) 1 C an impossibly large charge [1]

(b) **(i)** Slows down the rate of discharge [1]

(ii)



decreasing curve [1]
intercept on *Q*-axis, no intercept on *t*-axis [1]
Q_0 label [1]

[3]

(iii) Exponential (decay) curve [1]

(iv) Time taken for the charge on the capacitor to fall to 1/e (or 0.37) of its initial value. [1]

(v) $\tau = 47 \text{ x } 10^{-12} \times 22 \times 10^{6} = 1.03 \times 10^{-3}$ s [1]
14% approximately 2 time constants [1]
t = 2.1 ms [1] [11]

5 **(a)** **(i)** concentric circles [1]
Arrows anticlockwise [1]

(ii) upwards [1]

(b) $B = F/IL$ [1]
$B = 40 \times 10^{-3}/5.0 \times 0.10$ [1]
B = 0.08 (T) [1] [6]

6 **(a)** alternating pd across primary causing varying magnetic flux [1]
Core links flux to secondary [1]
Time varying flux in secondary induces alternating emf [1]

(b) $\frac{I_p}{I_s} = \frac{V_s}{V_p}$ [1]

$\frac{I_p}{1200} = \frac{240}{10.8 \times 10^3}$ [1]

$I_p = 26.7$ (A) [1]

(c) resistance heating/I^2R
magnetic fux leakage/magnetic hysteresis/eddy current heating of core [1] [7]

7 **(a)** **(i)** Spot moves up or down [1]
by 1.2 cm [1]

(ii) vertical line [1]
Length 1.6 cm [1]

(b) **(i)** sinusoidal wave [1]
each wave takes up 4 cm ($f = 10^4$ Hz $T = 100$ μs) [1]
12 V peak = amplitude of 2.4 cm [1]

(ii) time base adjusted [1]
to 10 μs/cm [1] [9]

8 **(a)** **(i)** electron, neutrino etc [1]

(ii) hadrons experience strong force, leptons do not
leptons fundamental, hadrons not, [1]

(b) **(i)** baryon 3 quarks, mesons quark, antiquark pair [2]

(ii) electrons: leptons - fundamental (no internal structure)
protons: baryons –uud quark combination
neutrons: baryons – ddu quark combination [3]

(c) sketch showing **all**:
Tubes, increasing length on common axis
Particle source at short tube end
Alternate electrodes connected to a.c supply [1]

Description:
alternating pd applied to electrode and phase change particles attracted [1]
Travel at constant speed in tube [1]
As speed increases electrodes increase in length [1] [11]

9 **(a)** (1) Incorrect [1]
– satellite only stationary relative to Earth's surface if it is moving with same period [1]
(2) Correct [1]
(3) Correct [1]
(4) Incorrect [1]
– *g* not constant [1]

Quality of Written Communication

2 marks

The candidate expresses ideas clearly and fluently, through well-linked sentences and paragraphs. Arguments are generally relevant and well structured. There are few errors of grammar, punctuation and spelling.

1 mark

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0 marks

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(b) **(i)** Power generated = 18% of Area × Power per unit area
= 18% of 40 ×1.5 [1]
Power generated = 10.8 kW [1]

(ii) (1) $E = hc/\lambda$ [1]
$= 6.64 \times 10^{-34} \times 3 \times 10^{8}/550 \times 10^{-9}$ [1]
$= 3.62 \times 10^{-19}$ J [1]

(2) No. of photons = power/energy of photon
$= 1.5 \times 10^{3}/3.62 \times 10^{-19}$ [2]

(iii) A rainbow [1] [16]

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Physics

Assessment Unit A2 3

Practical Techniques (Internal Assessment)

SPECIMEN PAPER

MARK SCHEME

Section A

1 Results

c reading (guide value 55 mm – 60 mm)			[1]	
evidence of repetition and averaging			[1]	
Table 1.1	Sets of *x*, *y* values	5 at 1 each	[5]	

Analysis

(a)	Graph: Axes labelled	[1]	
	Scales	[2]	
	Five points	[1]	
	Best straight line	[1]	
(b)	Read-offs, large triangle	[1]	
	Candidate's value of gradient (any unit, 0)	[1]	
(c)	Subs in **Equation 1.1**	[1]	
	t **in range 0.8 to 1.5** mm	[1]	

Uncertainties

Use of extreme lines to find range of values of *m*: two values of *m*	[2]	
Estimate of uncertainty in *c*	[1]	
Calculation of absolute uncertainty in *t*	[1]	[20]

2 Procedure

Was circuit diagram provided?	**No** (**Yes**, 0)	[3]
with correct diagram in **Fig. 2.1**		
Was assistance given in connecting circuit?	**No** (**Yes**, 0)	[2]

Results

Five values of *I*	1 each	[5]

Analysis

(a)	Graph: Axes labelled	[1]	
	Scales	[1]	
	Five points	[2]	
	Best straight line	[1]	
(b)	Large triangle	[1]	
	Candidate's value of gradient	[1]	
	Unit: **A**	[1]	
(c)	Subs in gradient = $VS/\pi\rho D$	[1]	
	S in range $\mathbf{7.5 \times 10^{-2}}$ **to** $\mathbf{8.0 \times 10^{-2}}$ mm^2	[1]	[20]

Section B

3 **(a)** **(i)** V = 100 ml by measuring cylinder [1]
T by stopwatch [1]
Repeat [1]

(ii) eg D by travelling microscope *or* vernier calipers [1]
two directions at right angles [1]
$r = D/2$ [1]
uncertainty consistent with method [1]

(iii) Run liquid thread up and down tube, check length [1]
if length constant, bore uniform [1]

Quality of Written Communication

2 marks

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1 mark

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0 marks

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(b) **(i)** Graph of lg T against lg r or ln T against ln r [1]
m = gradient [1]
$\lg T = \lg(\text{constant}) + m \lg r$ or equivalent ln [1]

(ii) Take intercept [1]
intercept = lg (ALV) or ln (ALV) [1]

(c) **1** Eg care in inserting tube in rubber bung [1]
2 Eg care not to poke projecting tube into eye [1]
eg slippery floor because of spilt water

(d) any graph showing T decreasing with increasing r [1]
correct curve [1] [20]

Useful Formulae for AS 1 and AS 2

The data and formulae sheet will provide the following information:

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	$1\ eV = 1.60 \times 10^{-19}$ J

The following equations may be useful in answering some of the questions in the examination:

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$	for a constant force
Hooke's Law	$F = kx$ (spring constant k)	

Sound

Sound intensity level/dB $= 10\,\mathrm{lg}_{10}\dfrac{I}{I_0}$

Waves

Two-source interference $\lambda = \dfrac{ay}{d}$

Light

Lens formula $\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$

Magnification $m = \dfrac{v}{u}$

Electricity

Terminal potential difference $V = \mathcal{E} - Ir$ (E.m.f $\mathcal{E}$; Internal Resistance r)

Potential divider $V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

de Broglie equation $\lambda = \frac{h}{p}$

Useful Formulae for A2 1 and A2 2

The data and formulae sheet will provide the following information:

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of a vacuum	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of a vacuum	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1} $\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9} \text{ F}^{-1}\text{ m}\right)$
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
(unified) atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27}$ kg
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	$1 \text{ eV} = 1.60 \times 10^{-19}$ J

The following equations may be useful in answering some of the questions in the examination.

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$	for a constant force
Hooke's Law	$F = kx$ (spring constant k)	

Simple harmonic motion

Displacement	$x = A\cos\omega t$

Sound

Sound intensity level/dB $= 10 \lg_{10} \frac{I}{I_0}$

Waves

Two-source interference $\lambda = \frac{ay}{d}$

Thermal physics

Average kinetic energy of a molecule $\frac{1}{2} m < c^2 > = \frac{3}{2} kT$

Kinetic theory $pV = \frac{1}{3} Nm < c^2 >$

Thermal energy $Q = mc\Delta\theta$

Capacitors

Capacitors in series $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

Capacitors in parallel $C = C_1 + C_2 + C_3$

Time constant $\tau = RC$

Light

Lens formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Magnification $m = \frac{v}{u}$

Electricity

Terminal potential difference $V = \varepsilon - Ir$ (E.m.f ε; Internal Resistance r)

Potential divider $V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

Radioactive decay $A = \lambda N$

$A = A_0 e^{-\lambda t}$

Half-life $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

de Broglie equation $\lambda = \frac{h}{p}$

The nucleus

Nuclear radius $r = r_0 A^{\frac{1}{3}}$

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