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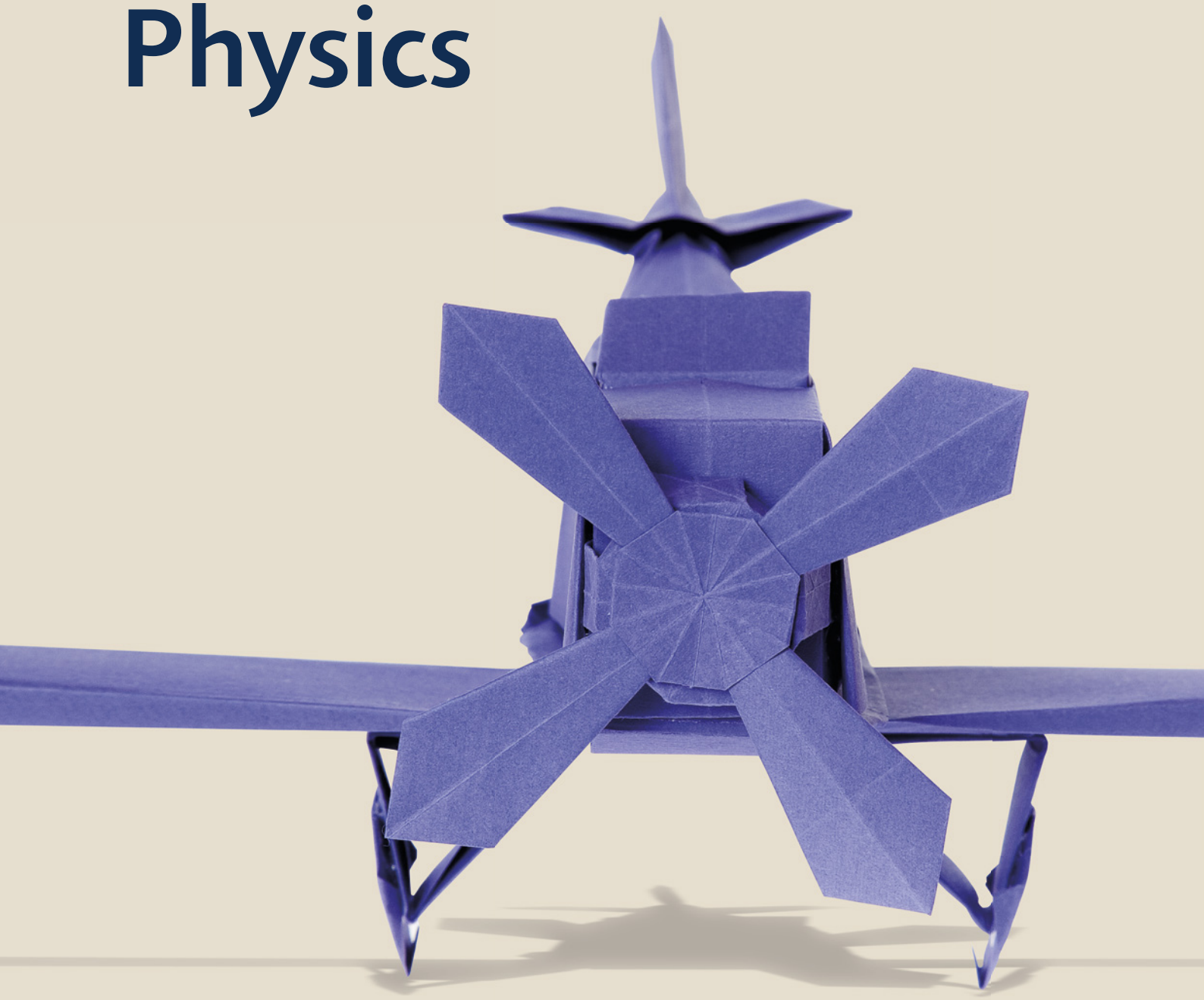
A Level Physics



Sample Assessment Materials

Pearson Edexcel Level 3 Advanced GCE in Physics (9PH0)

First teaching from September 2015

First certification from 2017 | Issue 1

edexcel

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Sample Assessment Materials

First certification 2017

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Contents

Introduction

The Pearson Edexcel Level 3 Advanced GCE in Physics is designed for use in schools and colleges. It is part of a suite of GCE qualifications offered by Pearson.

These sample assessment materials have been developed to support this qualification and will be used as the benchmark to develop the assessment students will take.

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the last candidate in exactly the same way as they mark the first.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than be penalised for omissions.
- Examiners should mark according to the mark scheme – not according to their perception of where the grade boundaries may lie.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification/indicative content will not be exhaustive.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, a senior examiner must be consulted before a mark is given.
- Crossed-out work should be marked **unless** the candidate has replaced it with an alternative response.

Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

Physics

Advanced
Paper 1: Advanced Physics I

Sample Assessment Materials for first teaching September 2015

Time: 1 hour 45 minutes

Paper Reference **9PH0/01**

You may need a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You may use a scientific calculator.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an *, marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations including units where appropriate.

Turn over ▶

S47558A

S 4 7 5 5 8 A 0 1 3 2

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Answer ALL questions.

All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Resistivity can be described correctly as

☒ **A** resistance of a unit length.

☒ **B** resistance per unit area.

☒ **C** resistance per unit volume.

☒ **D** resistance of a unit cube.

(Total for Question 1 = 1 mark)

2 A capacitor of 50 μC is charged to a potential difference of 12 V.

The energy stored on the charged capacitor in joules is given by

☒ **A** $0.5 \times 50 \times 10^{-6} \times 12^2$

☒ **B** $\dfrac{0.5 \times 50 \times 10^{-6}}{12^2}$

☒ **C** $\dfrac{0.5 \times 12^2}{50 \times 10^{-6}}$

☒ **D** $0.5 \times (50 \times 10^{-6})^2 \times 12$

(Total for Question 2 = 1 mark)

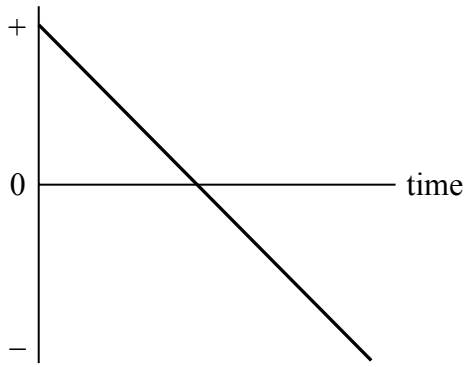
3 A bullet is fired into a block of wood. Select the line of the table that applies to this situation.

	Collision	Kinetic energy	Momentum
☒ **A**	elastic	conserved	conserved
☒ **B**	inelastic	not conserved	conserved
☒ **C**	elastic	conserved	not conserved
☒ **D**	inelastic	not conserved	not conserved

(Total for Question 3 = 1 mark)

4 A ball is thrown upwards, allowed to fall and is caught.

The graph represents its motion.



What quantity is plotted on the *y*-axis?

☒ **A** acceleration

☒ **B** displacement

☒ **C** speed

☒ **D** velocity

(Total for Question 4 = 1 mark)

5 Mains electricity in the UK is 230 V rms.

The peak voltage of the mains supply is given by

☒ **A** $\frac{230}{\sqrt{2}}$ V

☒ **B** $230\sqrt{2}$ V

☒ **C** $\frac{\sqrt{2}}{230}$ V

☒ **D** $\frac{230}{2}$ V

(Total for Question 5 = 1 mark)

6 The Large Hadron Collider is designed to accelerate protons to very high energies for particle physics experiments.

Very high energies are **not** required to

☒ **A** annihilate hadrons.

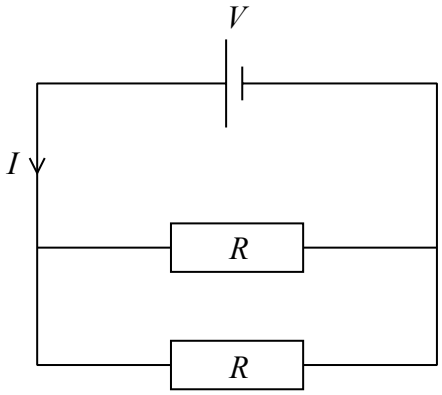
☒ **B** collide hadrons.

☒ **C** create particles with large mass.

☒ **D** create individual quarks.

(Total for Question 6 = 1 mark)

7 A potential difference, V, is applied to two resistors in parallel, each of resistance R. A current, I, flows through the whole circuit.



The correct expression for the power developed in each resistor is given by

☒ **A** $P = IV$

☒ **B** $P = IV/4$

☒ **C** $P = V^2/2R$

☒ **D** $P = I^2R/4$

(Total for Question 7 = 1 mark)

8 The joule can be expressed in SI base units as

☒ **A** kg m s^{-2}

☒ **B** kg m^2 s^{-1}

☒ **C** kg m^2 s

☒ **D** kg m^2 s^{-2}

(Total for Question 8 = 1 mark)

9 Which of these is **not** made from quarks?

☒ **A** proton

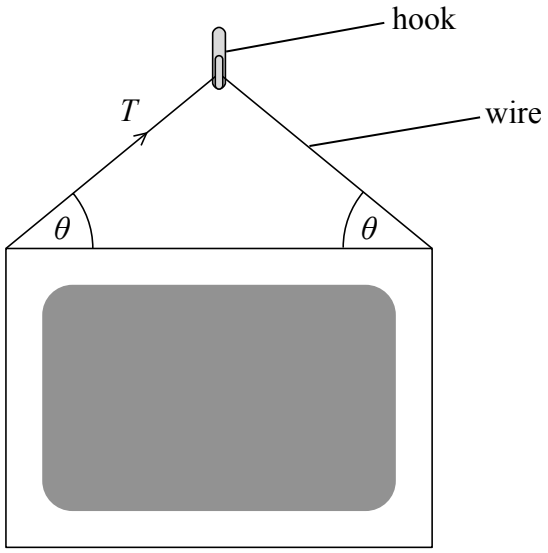
☒ **B** neutron

☒ **C** lepton

☒ **D** meson

(Total for Question 9 = 1 mark)

10 A picture with mass *m* hangs from a hook by a single length of wire. The hook is at the midpoint of the wire.



The tension *T* in the wire is given by

☒ **A** $\frac{mg}{2\sin\theta}$

☒ **B** $\frac{mg}{2\cos\theta}$

☒ **C** $\frac{mg}{\sin\theta}$

☒ **D** $\frac{mg}{\cos\theta}$

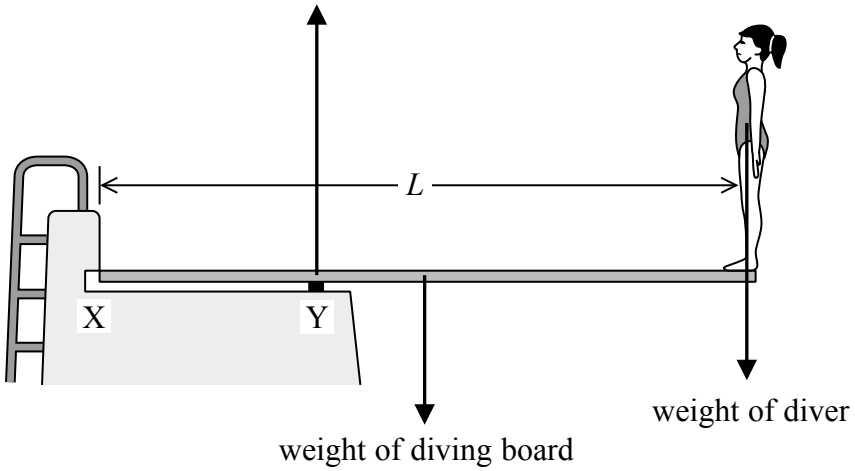
(Total for Question 10 = 1 mark)

11 Rutherford's alpha-scattering experiment gave evidence that changed our understanding of the structure of the atom. Alpha particles were fired at a thin sheet of gold foil and their paths observed.

Explain how the observations of the different paths taken by the alpha particles as they passed through the gold foil led to a new model of the atom.

(Total for Question 11 = 4 marks)

12 The diagram shows a diver of weight 680 N on a diving board.



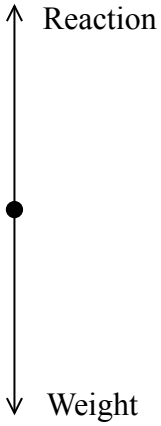
(a) The diving board has a length L of 3.6 m and is fixed at the end labelled X. It is supported at position Y which is 0.9 m from X. The diving board is uniform and has a weight of 390 N.

By taking moments about X, determine the upward force exerted by the support at Y on the diving board.

(5)

Force = ...

(b) The free-body force diagram for the diver standing on the board is shown.



The two forces shown do **not** form a Newton third law pair.

Give **two** reasons why.

(2)

.....

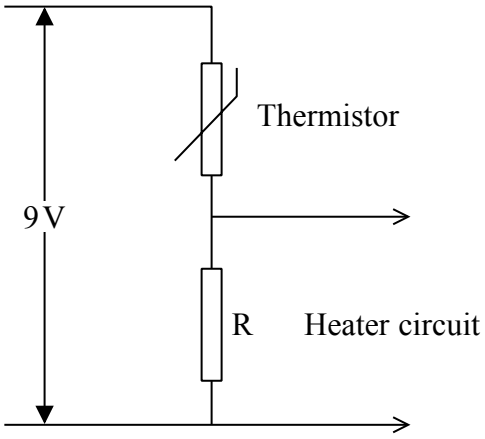
.....

.....

.....

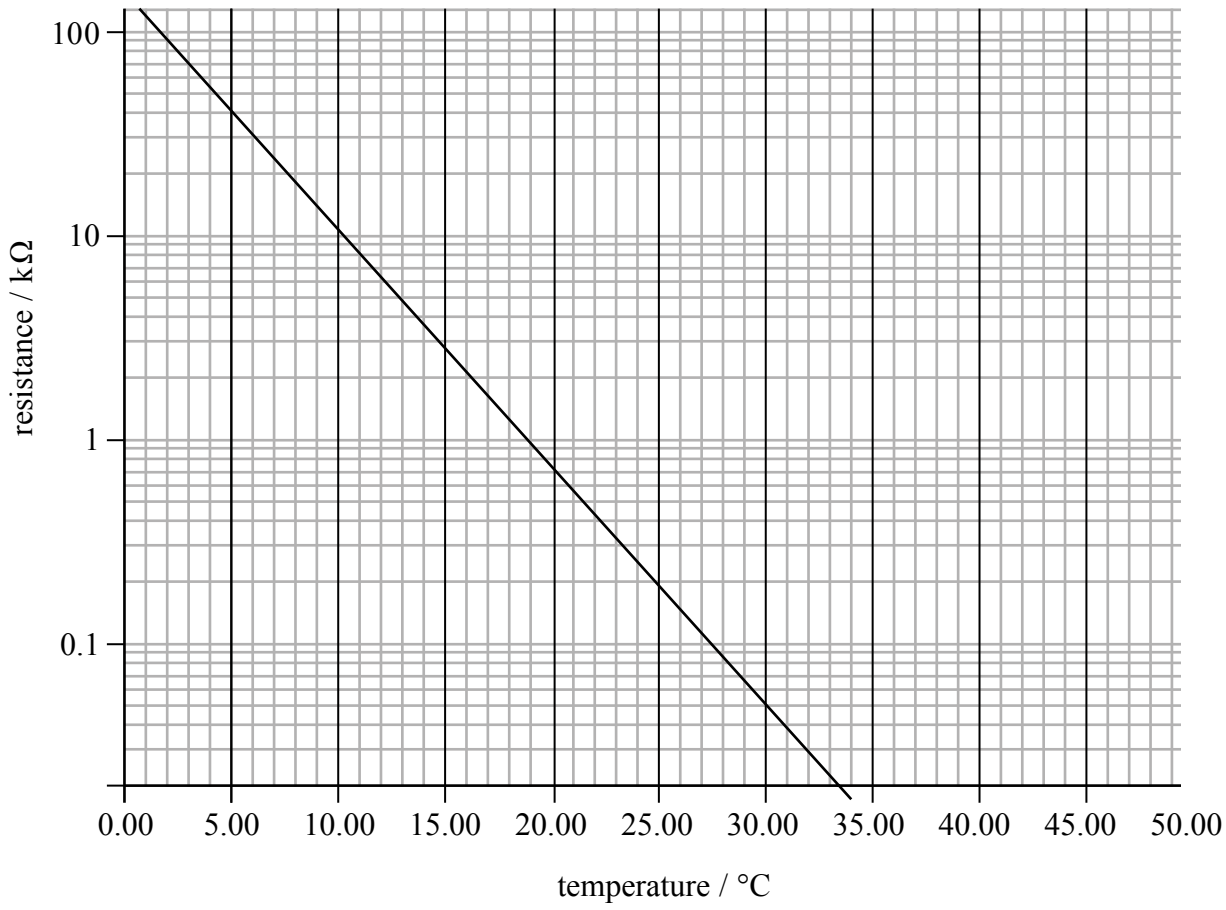
(Total for Question 12 = 7 marks)

13 A thermistor can be used to control a heater. When the temperature falls below a certain value the heater is switched on. The thermistor is connected in series with a fixed resistor R in a potential divider circuit as shown.



The heater circuit is connected across R and will switch on when the potential difference across it is above 5.5 V.

The variation of resistance of the thermistor R_T with temperature is shown on the graph.



(Source: http://reviseomatic.org/help/e-resistors/ThermistorLogGraph.gif)

(a) With reference to charge carriers, explain why the resistance of the thermistor R_T, changes with temperature.

(2)

(b) The heater switches on when the temperature falls below 20 °C.

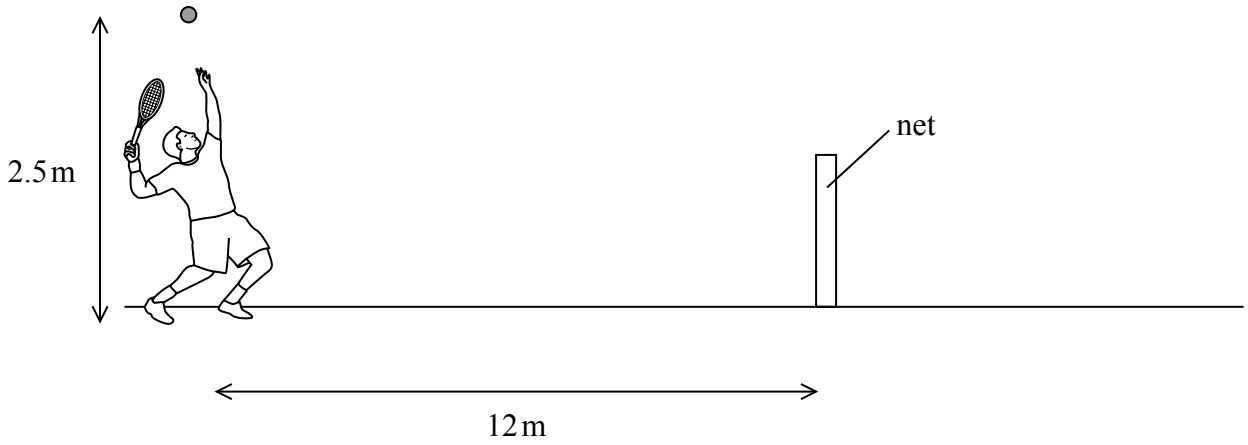
Calculate the resistance of the fixed resistor R.

(3)

Resistance = ...

(Total for Question 13 = 5 marks)

14 A tennis player uses a racket to hit a ball over a net.



The player stands 12 m from the net. He throws the ball vertically upwards and hits the ball at a height of 2.5 m above the ground. The ball leaves the racket **horizontally** with a velocity of 25 m s^{-1}. The ball has a mass of 0.06 kg.

(a) The ball is in contact with the racket for 0.04 s.

Calculate the average force on the ball.

(3)

Average force = ...

(b) The ball must land within 6.1 m of the other side of the net.

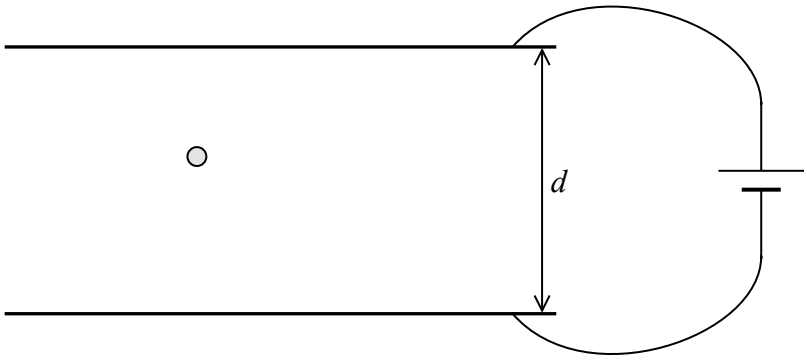
Determine whether the ball hits the ground within this distance. Support your answer with a calculation. Ignore the height of the net.

(6)

(Total for Question 14 = 9 marks)

15 In an experiment to determine the charge on an electron, negatively charged oil drops are allowed to fall between two parallel metal plates separated by a distance *d*.

A potential difference (p.d.) is applied across the plates. The diagram shows one oil drop between the plates.



When the p.d. is 0 V the oil drop accelerates to terminal velocity. The p.d. is increased. It is observed that at a particular p.d. *V* the oil drop stops falling and remains stationary between the plates.

*(a) Explain the motion of the oil drop in terms of the forces acting on it as the p.d. is increased from 0 to *V*.

(6)

(b) The oil drop has a mass m. Show that the charge q on the oil drop is given by

$$q = \frac{mgd}{V}$$

(2)

(c) Explain what would happen to the oil drop if the p.d. is increased further.

(2)

(Total for Question 15 = 10 marks)

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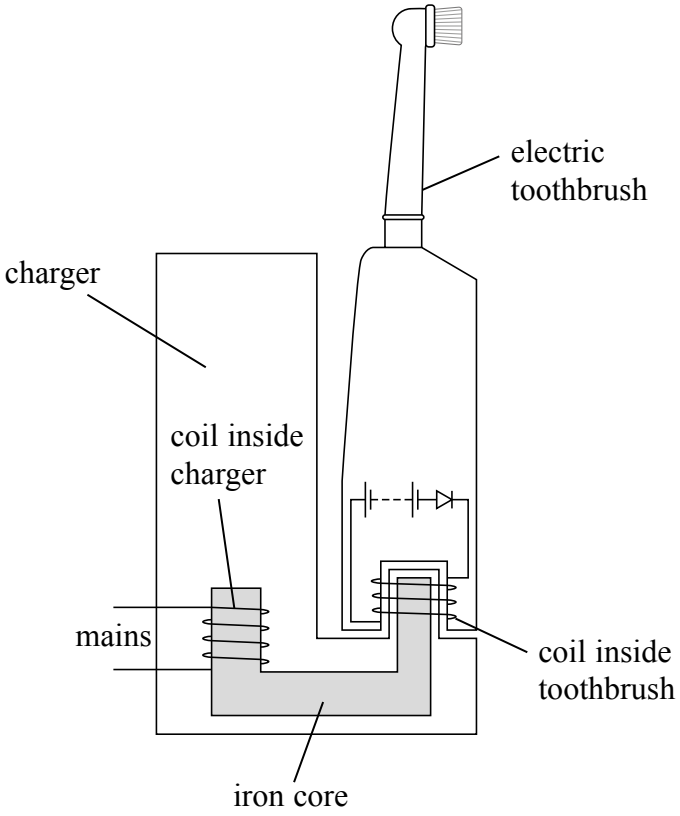
16 The diagram shows the inside of an electric toothbrush and a charger.

The charger contains a coil wrapped around an iron core. The coil is plugged into the mains a.c. supply.

The toothbrush also contains a coil that sits around the iron core when the toothbrush is placed on the charger to recharge the battery of the toothbrush.

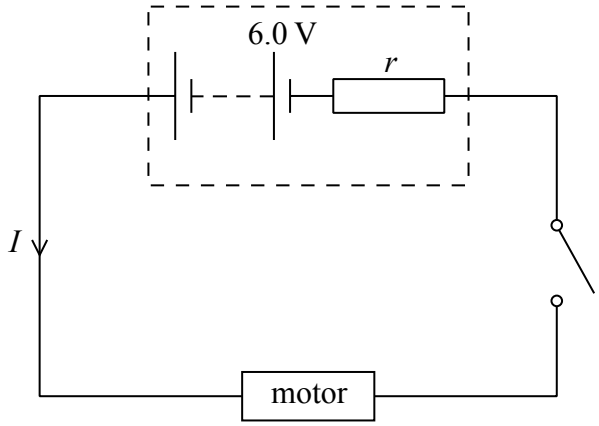


*(a) Describe how the charger is able to charge the low-voltage battery.

(6)

(b) When fully charged the battery has an e.m.f. of 6 V.

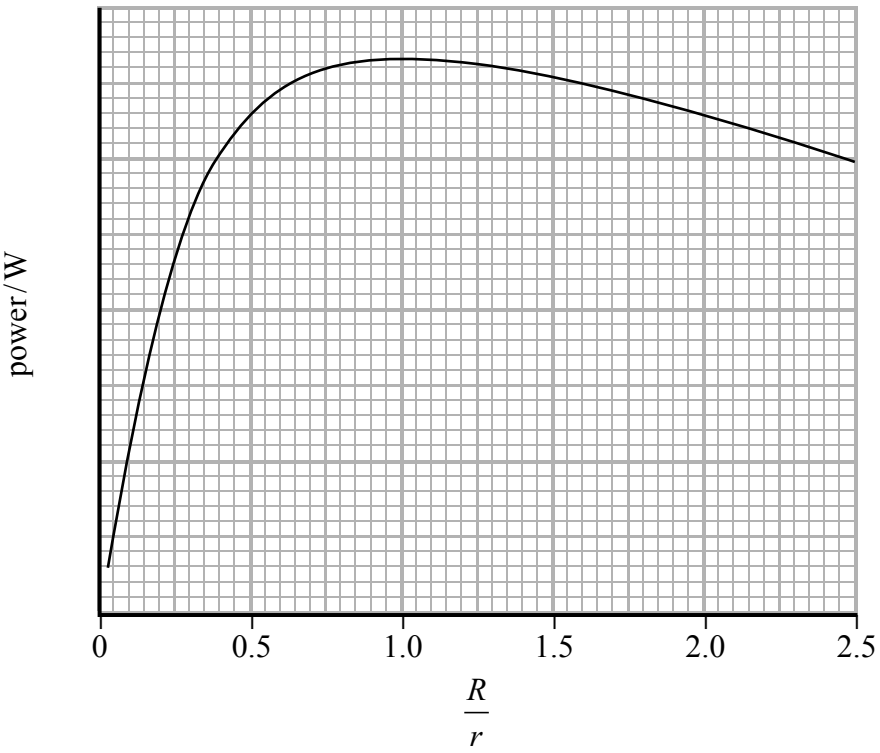
When the toothbrush is in use, the battery supplies a current of 57 mA with a terminal p.d. of 2.7 V to a motor.



(i) Show that the resistance of the motor R is about 50 Ω.

(1)

(ii) The power transferred from the battery to the motor depends on the ratio $\frac{R}{r}$ as shown in the graph below.



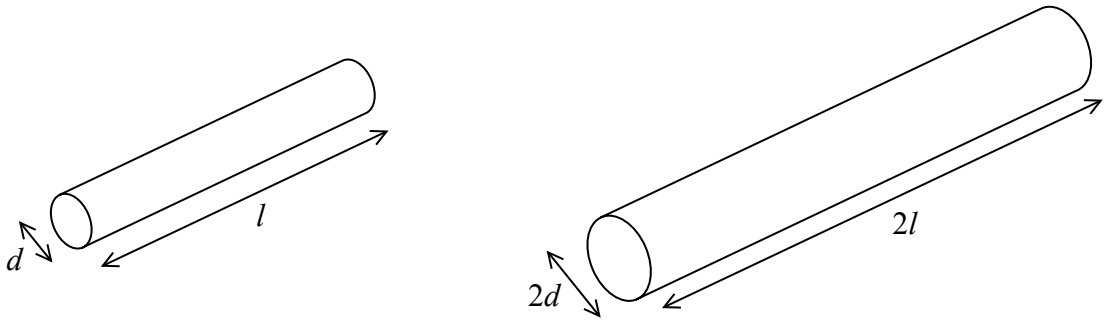
Determine whether maximum power is transferred to the motor.

(3)

(Total for Question 16 = 10 marks)

17 Pencil lead is a mixture of graphite and clay. The proportions of graphite and clay in the sample determine the hardness of the pencil lead, as well as the resistivity.

(a) The diagram shows two samples of pencil lead made from the same mixture of graphite and clay.



Sample A has a resistance R_A. Sample B has a resistance R_B and is twice the length and twice the diameter of sample A.

Calculate the ratio R_B/R_A.

(2)

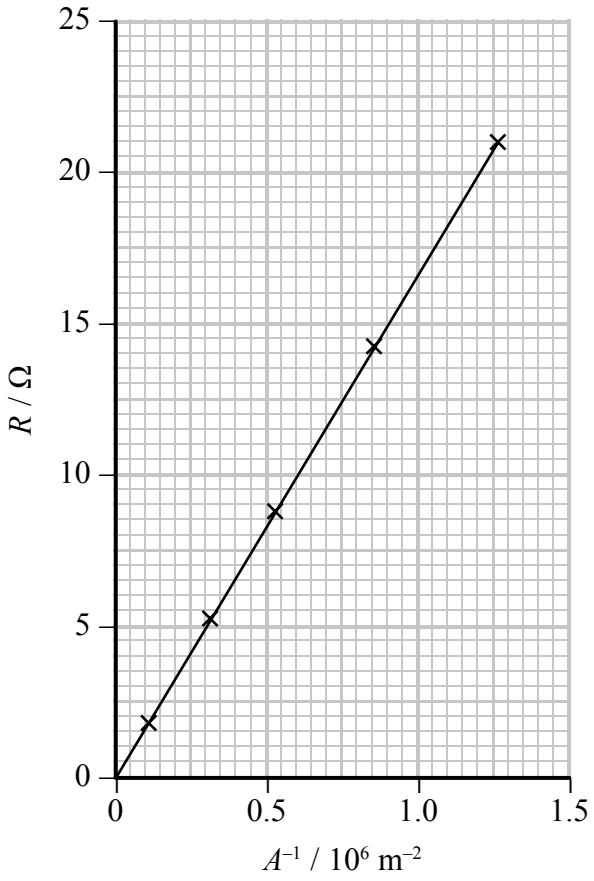
.....

.....

.....

R_B/R_A = ...

(b) A graph supplied by the manufacturer shows that the resistance R of a pencil lead is inversely proportional to its cross-sectional area A.



The resistivity of graphite is 3×10^{-5} Ω m. Use the graph to draw a conclusion about the effect of adding clay to graphite.

Length of pencil lead = 15.0 cm.

(4)

(c) Resistance can also be affected by temperature.

Explain why the resistance of a metal sample increases with an increase of temperature.

(3)

(Total for Question 17 = 9 marks)

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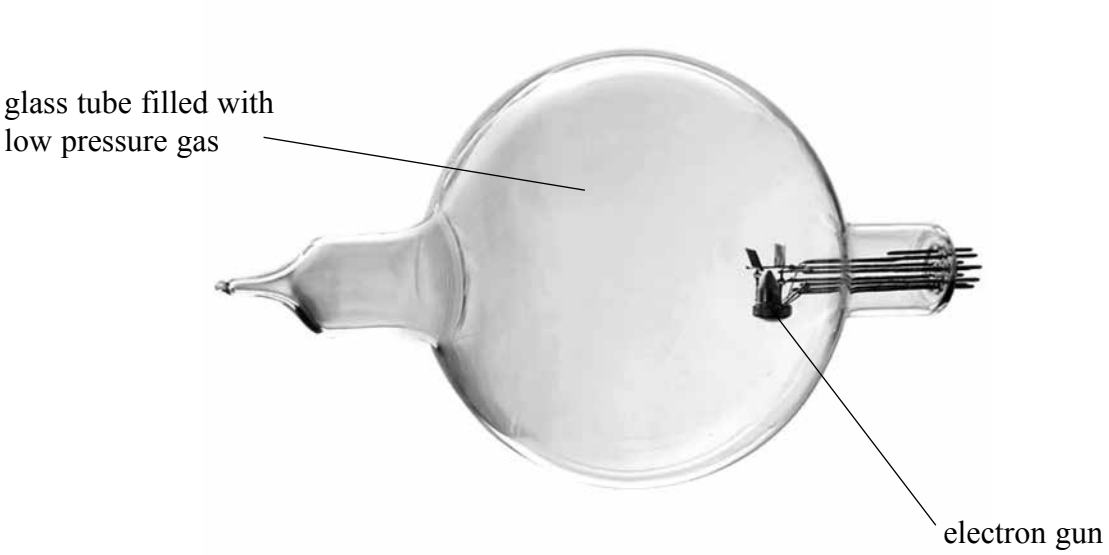
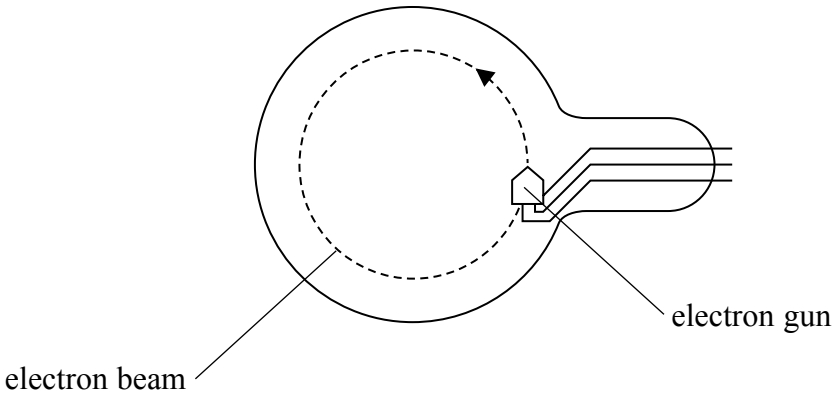
TURN OVER FOR QUESTION 18

18 An electron beam tube can be used to demonstrate the deflection of electrons in a uniform magnetic field. The tube contains a very low pressure gas so that electron paths can be seen.



(Source: http://www.klingereducational.com/images/products/thumbs/555571.jpg)

Electrons are emitted from the electron gun travelling vertically upwards into a region of uniform horizontal magnetic flux density.



(a) Show that the unit of magnetic flux density (Tesla) in SI base units is kg A^{-1} s^{-2}.

(2)

(b) Explain why the electrons follow a circular path.

(3)

(c) The magnetic flux density is varied while the speed of the electrons remains constant. The following data is obtained.

Radius/cm	Magnetic flux density/mT	
8.0	0.63	
9.5	0.52	
11.0	0.46	

Theory suggests that the radius of the electron path is inversely proportional to the magnetic flux density.

Analyse the data and comment on this suggestion, you may use the table to show any calculated values.

(4)

(Total for Question 18 = 9 marks)

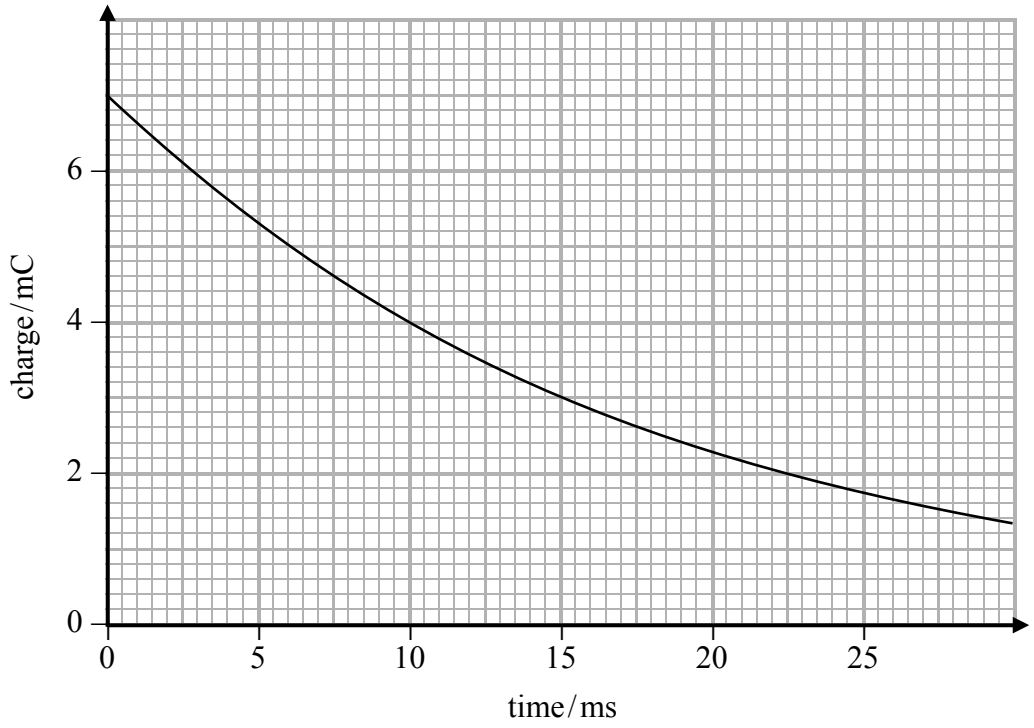
19 Some mobile phones have a capacitor touch screen made up of a sheet of glass with a thin metallic coating. The screen is charged and when it is touched some of the charge is transferred to the user. This causes a drop in electrical potential at the point where the screen is touched.

(a) A capacitor is charged by connecting it across a battery and then discharged through a resistor. In the case of the touch screen the user provides a discharge resistance of about 900 Ω.

Explain how the capacitor discharges.

(3)

(b) A capacitor is discharged through a resistor of resistance 900 Ω. The graph shows how the charge on the capacitor decreases with time.



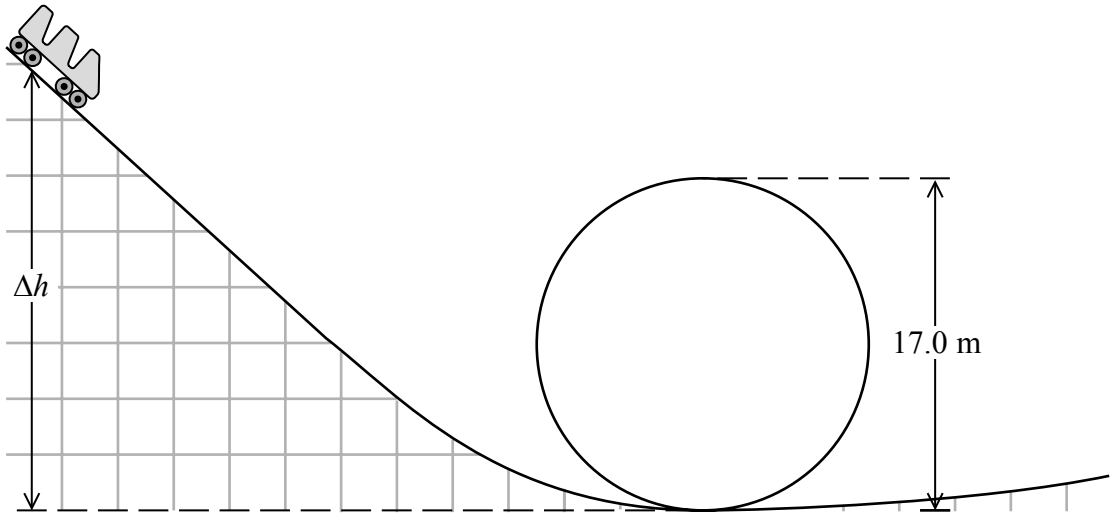
Calculate the capacitance of the capacitor.

(4)

Capacitance = ...

(Total for Question 19 = 7 marks)

20 The diagram shows the carriage of a rollercoaster about to enter a vertical loop of diameter 17.0 m. The carriage is initially at rest at a height Δh above the bottom of the loop.



(a) (i) So that a passenger remains in contact with their seat at the top of the ride, show that the minimum speed of the car at the top of the loop is 9.1 m s^{-1}.

(3)

(ii) Calculate the minimum value of Δh that will enable the passenger to remain in contact with their seat at the top of the loop.

(3)

$\Delta h =$ .....

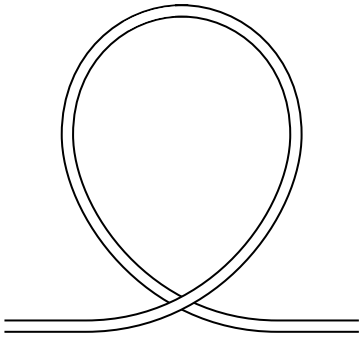
(b) During one particular ride, the speed of a car at the bottom of the loop was 22.5 m s^{-1}.

(i) Calculate the acceleration of the passenger at the bottom of the loop as a multiple of g, the acceleration due to gravity.

(2)

Acceleration = ...

(ii) The maximum safe acceleration recommended for passengers is 4*g*. Most loop-the-loop rollercoasters do not have a circular loop. Instead, the radius of curvature of the loop varies.



Explain why making the radius of the loop vary in this way enables the acceleration at the bottom of the loop to be less than 4*g*.

(2)

.....

.....

.....

.....

(Total for Question 20 = 10 marks)

TOTAL FOR PAPER = 90 MARKS

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Paper 1 Mark scheme

Question number	Acceptable answers	Additional guidance	Mark
1	D		**1**
2	A		**1**
3	D		**1**
4	D		**1**
5	B		**1**
6	C		**1**
7	D		**1**
8	D		**1**
9	C		**1**
10	A		**1**

(Total for Multiple Choice Questions = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
11	An explanation that makes reference to: • Most alpha particles pass through undeflected **(1) OR** some deflected through a small angle **(1)** • A very small number are deflected through an angle greater than 900 **(1)** • This suggests that the alpha particles are deflected by a charged nucleus that has a very small diameter compared to that of the atom rather than the charge being distributed throughout the atom **(1)** • and that most of the mass of the atom is concentrated in the nucleus rather than distributed throughout the atom **(1)**		**4**

(Total for Question 11 = 4 marks)

Question number	Acceptable answers	Additional guidance	Mark
12 (a)	• Recognises that weight acts at midpoint of diving board 1.8 (m) from X **(1)** • Use of moment = perpendicular force x distance **(1)** • Total clockwise moment = 3150 Nm **(1)** • Recognises that clockwise moment = anticlockwise moment **(1)** • F=3500 N **(1)**	Example of calculation: Total clockwise moment = (680x3.6)+(390x1.8) = 3150 Nm F = 3150/0.9 = 3500 N	**5**
12 (b)	• The forces are different types **(1)** • The forces act on the same object **(1)**		**2**

(Total for Question 12 = 7 marks)

Question number	Acceptable answers	Additional guidance	Mark
13 (a)	• The number of charge carriers increases with temperature **(1)** • So this lowers the resistance (despite the increase in lattice vibrations) **(1)**	Accept number of electrons.	**2**
13 (b)	• R_T = 0.7 – 0.8 kΩ [read from graph] **(1)** • Use of $V=IR$ (with 3.5 V and R_T) to find I **and** $V=IR$ (with V = 5.5 V) to find R **(1)** • R=1100 – 1300 Ω **(1)**	Accept use of $Vo = Vs\left(\frac{R_1}{R_1 + R_2}\right)$ Or $V_{out}/(V_s - V_{out})$ x R_T = R Example of calculation: $I = \frac{3.5}{750} = 0.0047$ A $R = \frac{5.5}{0.0047} = 1170\ \Omega$	**3**

(Total for Question 13 = 5 marks)

Question number	Acceptable answers	Additional guidance	Mark
14 (a)	**Either** • Calculate acceleration **(1)** • Use of $F = ma$ **(1)** • F = 38 N **(1)** **OR** • Calculate change in momentum **(1)** • Use of $F = \frac{\Delta mv}{\Delta t}$ **(1)** • F = 38 N **(1)**	Example of calculation: $F = \frac{0.06\ x\ 25}{0.04} = 37.5$ N	**3**
14 (b)	• Use of $s = ut + \frac{1}{2}at^2$ **(1)** • Use of $s = \frac{1}{2}at^2$ with vertical components to find t **(1)** • Use of $s = ut$ with horizontal components to find s **(1)** • Subtract 12 from their answer for horizontal distance **(1)** • Distance from net = 6 m **(1)** • Makes conclusion whether the ball is within the required range of the net **(1)**	Answer consistent with calculated value. Example of calculation: $t = \sqrt{\frac{2 \times 2.5}{9.81}} = 0.714$ s $s = 25 \times 0.714 = 17.85$ m Distance from net = 17.85 – 12 = 5.9 m	**6**

(Total for Question 14 = 9 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>15 (a)*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
</td><td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td></td></tr>
</table>

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>15 (a)*
(continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td></td><td></td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
15 (a)* (continued)	**Indicative content** • At terminal velocity the forces on the drop are balanced **OR** weight = drag • The p.d. creates an electrostatic force acting upwards on the drop • The electrostatic force increases as p.d. increases • The net upward force causes the drop to have a negative acceleration • As speed decreases the drag decreases • The drop remains stationary when the forces are balanced **OR** until the drop remains stationary when weight = electrostatic force		**6**
15 (b)	• Equate the electric force and the gravitational force **(1)** • Use of E=V/d to obtain $q = mgd/V$ **(1)**	$qE = mg$ $q(V/d) = mg$ $q = mgd/V$	**2**
15 (c)	An explanation that makes reference to: • Electrostatic/upward force (on drop) would be greater than the weight/downward force **(1)** • So drop would <u>accelerate</u> upwards **(1)**	Indication of which force is greater, unbalanced is insufficient.	**2**

(Total for Question 15 = 10 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>16 (a)*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>
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The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td></td></tr>
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<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td></td><td></td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
16 (a)* (continued)	**Indicative content** • The supply creates a changing magnetic field in the iron core • Rate of change of flux in toothbrush coil is equal to rate of change of flux in charger coil (for an ideal transformer) • The changing flux linkage in the coil of the toothbrush induces an e.m.f. according to Faraday's law • E = – N dφ/dt so to step down the e.m.f. there must be fewer turns in the toothbrush coil • The e.m.f. in the toothbrush coil must be larger than the toothbrush battery • Diode is included so battery is not discharged by the alternating e.m.f.	Allow provides dc to charge battery or similar.	**6**
16 (b)(i)	R= 47.4 Ω **(1)**	Example of calculation: R = 2.7 V/0.057 A = 47.4 Ω	**1**
16 (b)(ii)	• Use of $\mathcal{E}=V+Ir$ **or** correct attempt to find r **(1)** • r = 57.9 Ω or find ratio $\frac{R}{r}$ **(1)** • Makes conclusion by comparing r and R, recognising maximum power supplied when $\frac{R}{r} = 1$ **(1)**	Answer consistent with calculated value. Example of calculation: $r = \frac{(6.0\ V - 2.7\ V)}{0.057\ A} - 50 = 57.9\ \Omega$	**3**

(Total for Question 16 = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
17 (a)	• Use of: $R = \frac{\rho L}{A}$ **(1)** • $\frac{R_B}{R_A} = 0.5$ [accept 2:4 **or** 1:2 **or** 1/2] **(1)**	Example of calculation: $\frac{R_B}{R_A} = \frac{L_2 d_1^2}{L_1 d_2^2}$ $\frac{R_B}{R_A} = \frac{2Ld^2}{L(2d)^2} = \frac{2}{4} = 0.5$	**2**
17 (b)	• Correct transfer of data for gradient **(1)** • Large triangle used **(1)** • $\rho = 1.1 \times 10^{-4}$ Ωm **(1)** Conclusion: • 1.1×10^{-4} Ωm is greater than 3×10^{-5} Ωm, so resistivity increases when clay is added **(1)**	Answer to be consistent with calculated value. Example of calculation: Gradient = $\rho L = 16.5 \times 10^{-6}$ Ωm^2 $\rho = 16.5 \times 10^{-6}$ Ωm^2/0.15 m = 1.1×10^{-4} Ωm	**4**
17 (c)	An explanation that makes reference to: • A rise in temperature causes the amplitude of the vibrating ions to increase **(1)** • This causes the number of collisions per second between the ions and the moving electrons to increase **(1)** • So the rate of flow of electrons decreases (causing the resistance of the metal to increase) **(1)**	Allow reduce mean free path or drift velocity of electrons. Accept current decreases	**3**

(Total for Question 17 = 9 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>18 (a)</td><td>• Use of $F = BIl$ or use of $F=Bqv$ (1)
• Converts N to kg m s^{-2} (1)</td><td>Example
$B = \frac{F[\text{kg m } s^{-2}]}{I[\text{A}]\ l[\text{m}]}$
So units are kg A^{-1} s^{-2}</td><td>2</td></tr>
<tr><td>18 (b)</td><td>An explanation that makes reference to:
• The magnetic force on the electrons acts at right angles to the plane containing B and v (1)
• Hence the force is always towards the centre of the circle (1)
So providing a centripetal force on the electron or a centripetal acceleration that maintains circular motion (1)</td><td></td><td>3</td></tr>
<tr><td>18 (c)</td><td>• Calculates B x r (1)
• Calculate the percentage uncertainty (1)
• Suitable comment on difference from expectation (1)
• Weak conclusion because only three readings (1) OR no repeats (1) OR limited range (1)</td><td>Example of calculation:
%U = (0.06/5.01) x 100% = 1.2%
<table><tr><th>Radius /cm</th><th>Magnetic flux density/mT</th><th></th></tr><tr><td>8.0</td><td>0.63</td><td>5.04</td></tr><tr><td>9.5</td><td>0.52</td><td>4.94</td></tr><tr><td>11.0</td><td>0.46</td><td>5.06</td></tr></table></td><td>4</td></tr>
</table>

(Total for Question 18 = 9 marks)

Question number	Acceptable answers	Additional guidance	Mark
19 (a)	An explanation that makes reference to: • Electrons/charge transferred from negatively charged plate to positively charge plate through the resistor **(1)** • Hence the charge on capacitor decreases (exponentially) **(1)** • Until the charge on the capacitor equals 0/negligible **(1)**		**3**
19 (b)	**Either** • Use $Q = 2.6$ to read time constant from graph **(1) OR** draw tangent to curve at t = 0 and obtain time constant from intercept on x axis **(1)** • $t = 17 – 18$ (ms) **(1)** • Use of $T = RC$ with their T **(1)** • $C = 0.019$ - 0.021 mF **(1)** **OR** • $Q_0 = 7$ (mC) read from graph **(1)** • Any corresponding values of Q and t read from graph **(1)** • Use of $Q=Q_0 e^{-t/RC}$ with their values for Q_0, Q and t **(1)** • $C = 0.0195 – 0.0196$ mF **(1)** **OR** • $Q_0 = 7$ (mC) read from graph **(1)** • Q=3.5 (mC) when $T_{1/2} = 12.3$ (ms) **(1)** • Use of $T_{1/2} = RC \ln 2$ **(1)** • $C = 0.0195 – 0.0196$ mF **(1)**	Example of calculation: $T = 19$ (ms) $C = 19 \times 10^{-3}/900 = 0.021$ mF	**4**

(Total for Question 19 = 7 marks)

Question number	Acceptable answers	Additional guidance	Mark
20 (a)(i)	• Recognise that for passenger to remain in their seat normal reaction $R \geq 0$ **(1)** **or** centripetal force >= weight **(1)** • Equate centripetal force and weight (for R=0) **(1)** • $v = 9.1\ \text{m s}^{-1}$ **(1)**	Example of calculation: $\frac{mv^2}{r} = mg$ $v = \sqrt{rg} = \sqrt{8.5\text{m} \times 9.81\text{ms}^{-2}} = 9.13\text{ms}^{-1}$	**3**
20 (a)(ii)	• Equate decrease in gravitational potential energy to increase in kinetic energy at top of loop **(1)** • Adds this to 17.0 **(1)** • $\Delta h = 21.3$ m **(1)**	Example of calculation: $mgh = \frac{1}{2}mv^2$ $h = \frac{v^2}{2g} = \frac{\left(9.13\text{m s}^{-1}\right)^2}{2 \times 9.81\text{m s}^{-2}} = 4.25\text{m}$ $\Delta h = 17 + 4.3 = 21.3$ m	**3**
20 (b)(i)	• Use of $a = \frac{v^2}{r}$ **(1)** • $a = 6.1\text{g}$ **(1)**	Example of calculation: $a = \frac{v^2}{r} = \frac{\left(22.5\text{m s}^{-1}\right)^2}{8.5\text{m}} = 59.6\text{ms}^{-2}$ $a = 59.6/9.8 = 6.1$ g	**2**
20 (b)(ii)	An explanation that makes reference to: • Radius of curvature smallest at the top of the loop **(1) OR** radius larger at the bottom of the loop **(1)** • So acceleration at bottom is less for the same speed **(1)**		**2**

(Total for Question 20 = 10 marks)

Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number	Candidate Number

Physics

Advanced
Paper 2: Advanced Physics II

Sample Assessment Materials for first teaching September 2015
Time: 1 hour 45 minutes

Paper Reference
9PH0/02

You may need the Formulae Sheet, a ruler and a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You may use a scientific calculator.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an *****, marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations including units where appropriate.

Turn over ▶

S47559A

S 4 7 5 5 9 A 0 1 2 8

PEARSON

Answer ALL questions.

All multiple choice questions must be answered with a cross ☒ in the box for the correct answer from A to D. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A diverging lens is used to produce an image of a real object.

Select the row of the table that correctly identifies the nature of the image produced.

☒	**A**	Real	Upright
☒	**B**	Real	Inverted
☒	**C**	Virtual	Upright
☒	**D**	Virtual	Inverted

(Total for Question 1 = 1 mark)

2 When a sound wave passes from water into air it slows down. As the wave crosses the boundary from water to air its

☒ **A** frequency decreases.

☒ **B** frequency increases.

☒ **C** wavelength decreases.

☒ **D** wavelength increases.

(Total for Question 2 = 1 mark)

3 Standard candles are used by astronomers to determine the distances to distant star clusters.

A standard candle has a

☒ **A** constant brightness.

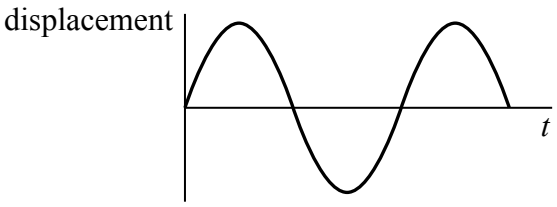
☒ **B** constant luminosity.

☒ **C** known brightness.

☒ **D** known luminosity.

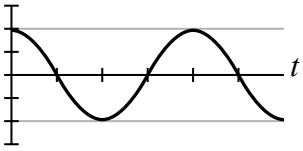
(Total for Question 3 = 1 mark)

4 The graph shows the variation of displacement with time for a particle undergoing simple harmonic motion.

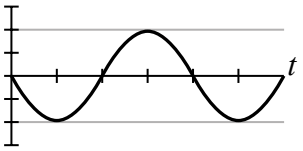


Select the graph that correctly shows the variation of velocity with time for the particle.

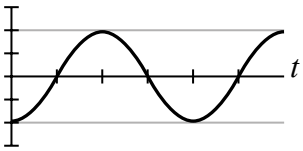
☒ **A**



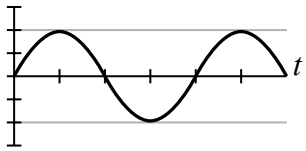
☒ **B**



☒ **C**

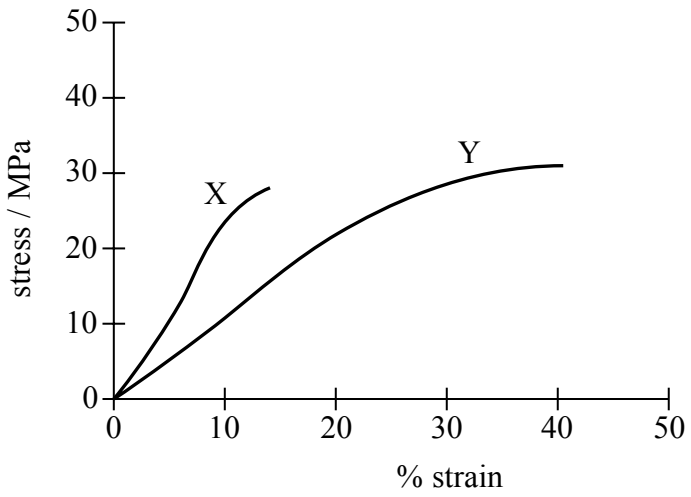


☒ **D**



(Total for Question 4 = 1 mark)

5 The graph shows the behaviour of two materials when placed under stress.



We can conclude from the graph that

☒ **A** material X is stiffer and stronger than material Y.

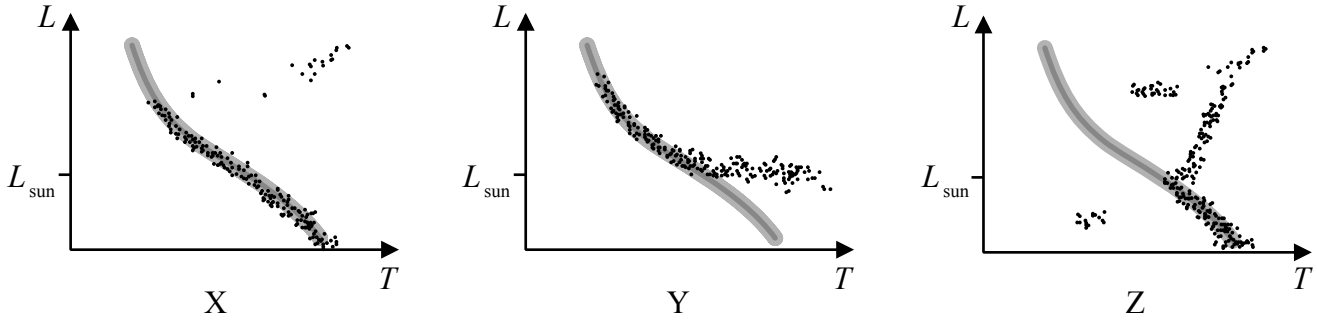
☒ **B** material Y is stiffer and stronger than material X.

☒ **C** material X is stiffer but weaker than material Y.

☒ **D** material Y is stiffer but weaker than material X.

(Total for Question 5 = 1 mark)

6 Hertzsprung-Russell diagrams are shown for three star clusters.



Choose the row that correctly identifies the relative ages of the three clusters.

	Youngest ⟶ Oldest		
☒ **A**	X	Z	Y
☒ **B**	Y	X	Z
☒ **C**	Y	Z	X
☒ **D**	Z	X	Y

(Total for Question 6 = 1 mark)

7 A planet moves around the Sun in a circular orbit of circumference $2\pi r$. The work done in one orbit on the planet by the gravitational force F is

☒ **A** 0

☒ **B** $\pi Fr/2$

☒ **C** πFr

☒ **D** $2\pi Fr$

(Total for Question 7 = 1 mark)

8 A small sphere is falling through a liquid. The viscous drag force acting on the sphere will increase if the

☒ **A** density of the liquid decreases.

☒ **B** radius of the sphere decreases.

☒ **C** temperature of the liquid decreases.

☒ **D** viscosity of the liquid decreases.

(Total for Question 8 = 1 mark)

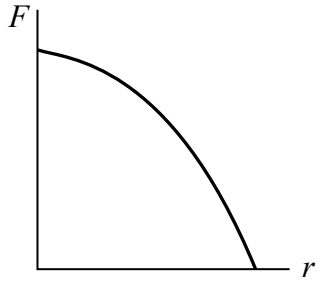
9 A converging lens is used as a magnifying glass. An image is produced that is 30 cm away from the lens and twice as big as the object.

Choose the row that correctly identifies the nature of the image and the object distance.

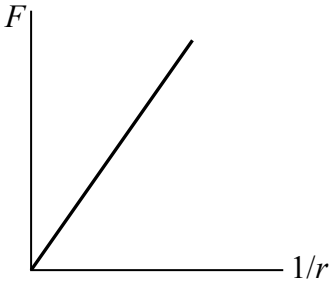
	Nature of image	Object distance/cm
☒ **A**	real	15
☒ **B**	real	60
☒ **C**	virtual	15
☒ **D**	virtual	60

(Total for Question 9 = 1 mark)

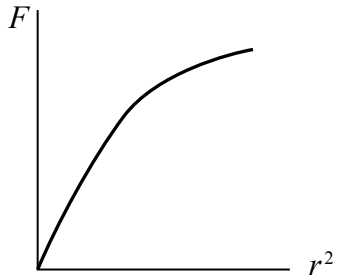
10 Select the graph that shows correctly the relationship between the gravitational force F between two masses and their separation r.



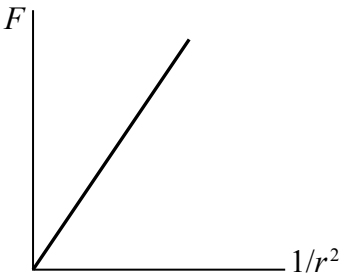
A



B



C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 10 = 1 mark)

11 (a) State what is meant by binding energy.

(2)

(b) In a nuclear fission reaction in power station, a slow-moving neutron is absorbed by a nucleus of U-235
The fission reaction produces nuclei of barium-141 and krypton-92

The equation for the reaction is:

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{141}_{56}\text{Ba} + ^{92}_{36}\text{Kr} + 3 \times ^{1}_{0}\text{n}$$

Use the data in the table to calculate the energy, in joules, released in this fission reaction.

(3)

	Mass/u
neutron	1.008665
uranium-235	235.0439
barium-141	140.9144
krypton-92	91.9262

Energy = ... J

(Total for Question 11 = 5 marks)

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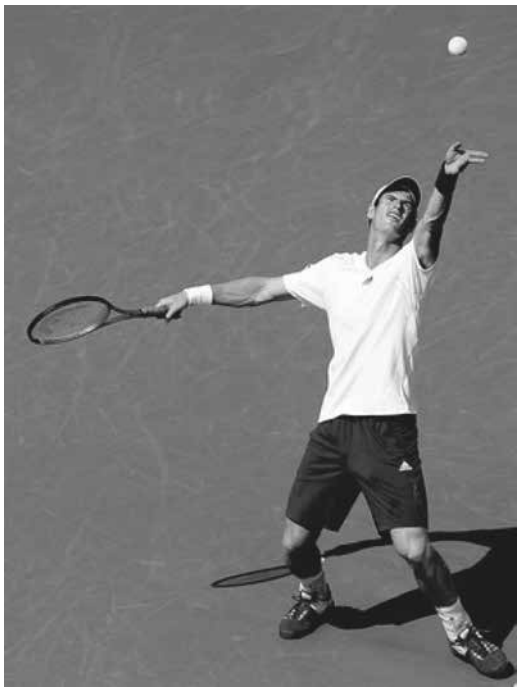
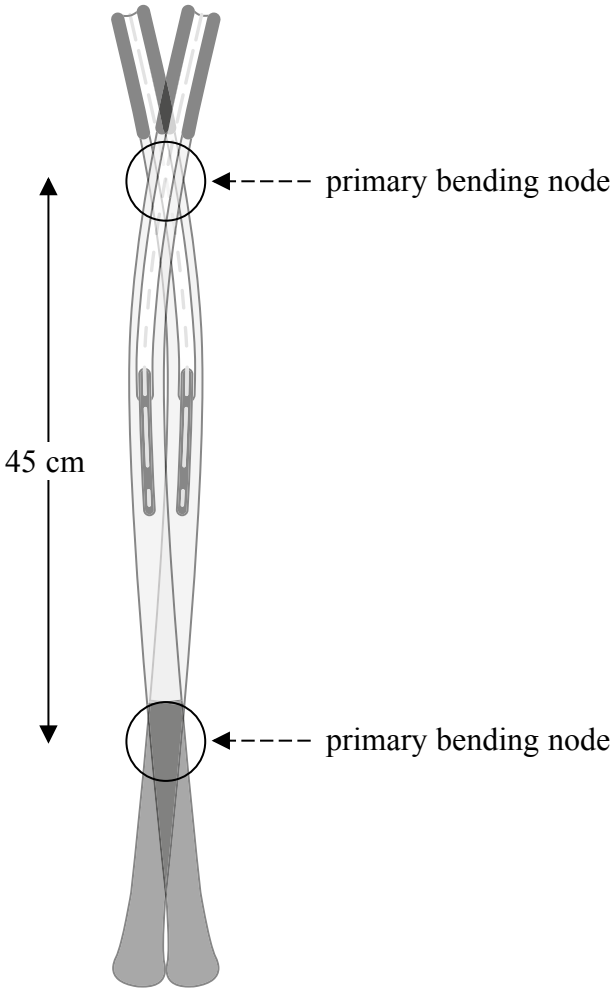
TURN OVER FOR QUESTION 12

12 A tennis player uses a racket to hit a ball over a net. When the racket strikes the ball the racket frame is set into oscillation.

(a) The fundamental mode of oscillation is shown. Transverse waves travel along the length of the racket at a speed of 160 m s^{-1}.



© Getty images

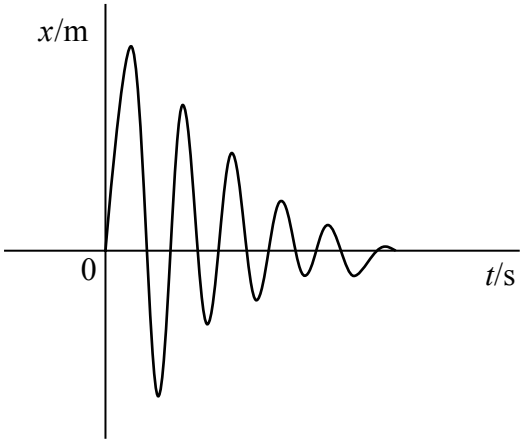


Calculate the frequency of oscillation of the frame.

(3)

Frequency = ...

(b) The graph shows how the displacement x of the centre of the frame varies with time t immediately following the strike.



Hollow spaces are built into the racket frame and small lead spheres are packed into these spaces.

Explain how this results in the graph shown.

(3)

(Total for Question 12 = 6 marks)

***13** The photograph shows a pipe organ in a concert hall.

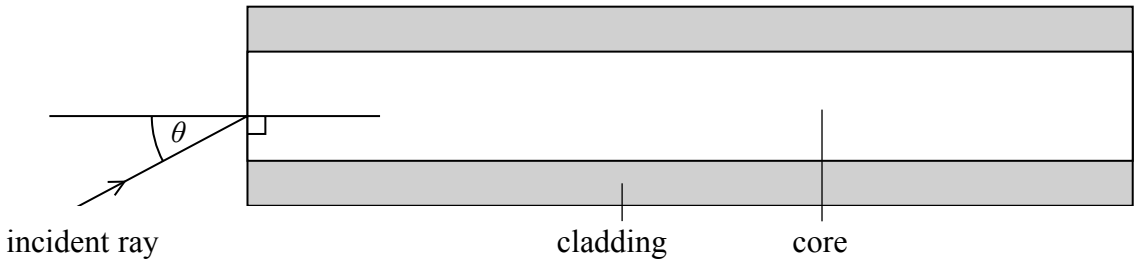
(Source: www.yucatanliving.com/article-photos/news/01042010/pipe-organ.jpg)

When the organ is played, sound travels through the air to a person in the audience as a wave. It is found that there are some positions in the concert hall where particular frequencies are quieter than others.

Explain why this might be the case and give an action that could be taken to eliminate this problem.

(Total for Question 13 = 6 marks)

14 (a) One type of optical fibre is made from a glass core surrounded by a glass cladding of lower refractive index. The light ray passes along the fibre by total internal reflection. The diagram shows a light ray incident on one end of the fibre.



A light ray enters the core with an angle of incidence θ and the angle of refraction is 20°.

Show that the light ray will be totally internally reflected when it meets the boundary between the core and the cladding.

$n_{core} = 1.56$

$n_{cladding} = 1.44$

(4)

(b) Magnifying ‘bug boxes’ are used to observe small insects. One type consists of a clear plastic pot with a snap-on lid.

The lid acts as a converging lens of focal length 8.5 cm.

An insect inside the box appears to be 3.5 times bigger when viewed through the lid.

(i) Draw a ray diagram to show the formation of the image by the lens when used in this way.

(3)

(ii) Calculate the distance of the insect from the lid.

(3)

(Total for Question 14 = 10 marks)

15 An electric drinks cooler is an appliance consisting of a thermally insulated compartment and a heat pump that transfers heat from the inside of the cooler to the room in which the cooler is placed.

This maintains the temperature of the inside of the cooler below the temperature of the room.

(Source: http://www.americanas.com.br/produto/110863245/adega-de-vinhos-easycooler-12 garrafas)

On closing the door of the cooler, warm air at atmospheric pressure and at a temperature of 22.5°C is trapped inside. After a time, the internal temperature stabilises at 3.3°C.

A student notices that the door is difficult to open and concludes that this is because the air inside has cooled down and reduced the pressure.

Carry out a calculation to assess the validity of the student's conclusion.

atmospheric pressure = 102 kPa

area of door = 0.15 m^2

(Total for Question 15 = 7 marks)

16 The picture shows a toy hanging from a spring.

(Source: m4.sourcingmap.com/photo_new/20120821/g/ux_a12082100ux0119_ux_g03.jpg)

The toy has a mass of 0.066 kg. When it is hanging freely on the spring, the spring extends by 4.5 cm.

When the toy is pulled downwards and released, it undergoes simple harmonic motion.

Calculate the frequency of the oscillations.

Frequency = ...

(Total for Question 16 = 5 marks)

17 Tomatoes can be made into a puree.

(a) The puree is heated. When the puree boils, its temperature stays constant, even though the puree continues to be heated.

Explain this observation in terms of molecular energy changes.

(2)

(b) The tomato puree has a mass of 0.444 kg and boils at 101°C. 175 kJ of energy are supplied to bring it to its boiling point from a temperature of 21°C.

Determine the specific heat capacity of the puree.

(2)

Specific heat capacity = ...

(c) The mass of the puree is reduced by boiling. The saucepan is heated by a radiant electric heater run from a mains supply which has a peak voltage of 325 V. The peak current in the heater is 12.4 A.

Calculate the time taken to reduce the mass of the puree at boiling point by 0.225 kg.

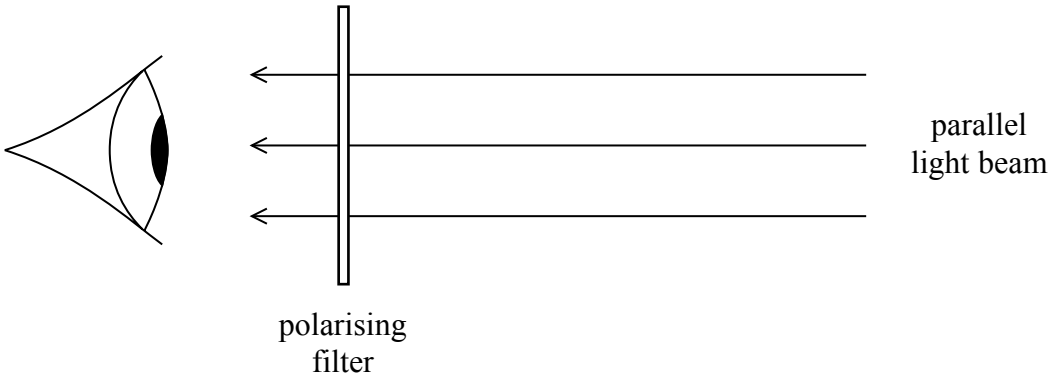
Specific latent heat of vaporisation of tomato puree = 2.37×10^6 J kg^{-1}

(4)

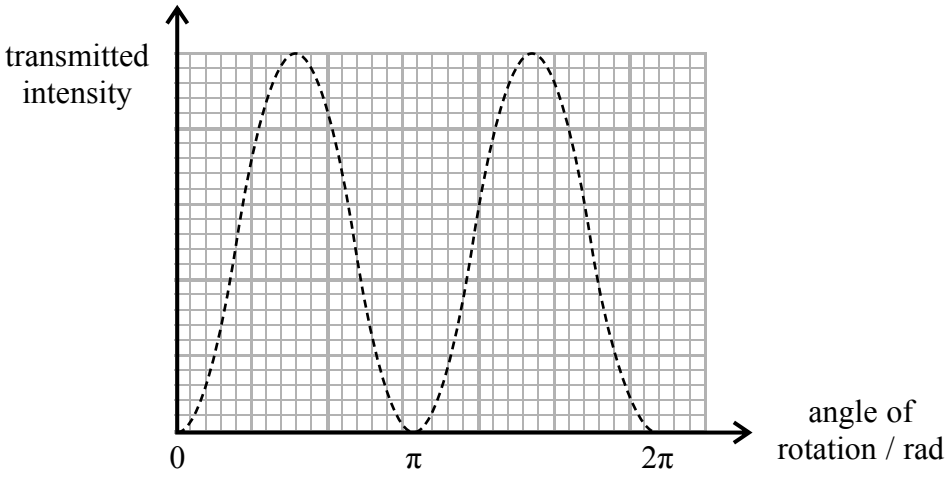
Time = ...

(Total for Question 17 = 8 marks)

18 A student observes a parallel beam of light through a polarising filter.



The polarising filter is rotated through 2π rad in its own plane. The intensity of the light transmitted through the filter varies as shown.



*(a) Explain the observed variation in intensity of the transmitted beam.

(6)

(b) Some sunglasses have lenses made from polarising filters.

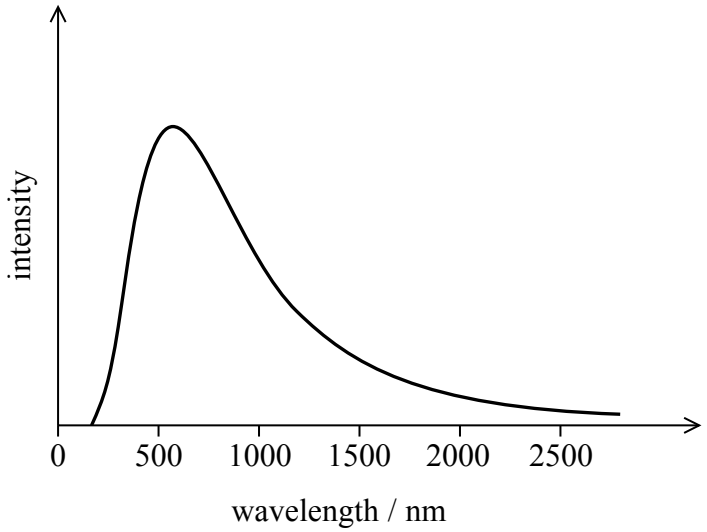
You are given two pairs of identical sunglasses.

Devise a simple test to determine whether the sunglasses use polarising lenses.

(2)

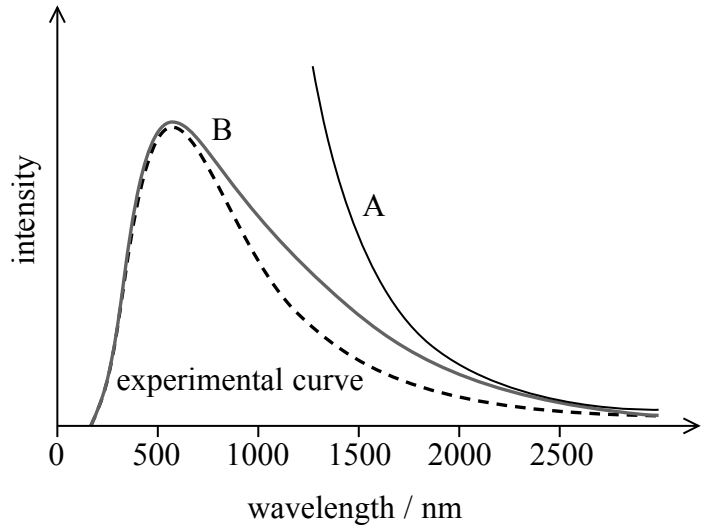
(Total for Question 18 = 8 marks)

19 The diagram shows the radiation curve for a black body radiator. The diagram was obtained from experimental data.



Experimental curve

In the late 19th century, scientists struggled to explain this experimental curve. One model used ideas of classical physics and produced curve A. Another model incorporated the idea of energy quantisation in the mechanism of energy emission and produced curve B. Both curve A and curve B are shown below, with the experimental curve for comparison.



(a) (i) Explain how energy quantisation applies to the emission of radiation of energy from a black body radiator.

(2)

(ii) Assess the extent to which each model is successful at explaining the experimental curve.

(4)

(b) The idea of energy quantisation was used to explain the photoelectric effect, first observed by Heinrich Hertz.
When ultraviolet radiation is shone onto a metal surface, electrons may be released.
A cadmium surface is illuminated with light of wavelength 2.54×10^{-7} m.

Calculate the maximum kinetic energy of the photoelectrons released from the surface.

Work function of cadmium = 4.07 eV

(4)

Maximum kinetic energy = ... J

(Total for Question 19 = 10 marks)

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TURN OVER FOR QUESTION 20

20 About 100 years ago the first measurements of spectra from galaxies beyond the Milky Way were made. Wavelengths of spectral lines were observed to be shifted and Hubble discovered a rough correlation between the shift in the spectral line and the distance to the galaxy.

The graphs below show plots for data collected in 1929 (Figure 1) and 1931 (Figure 2).

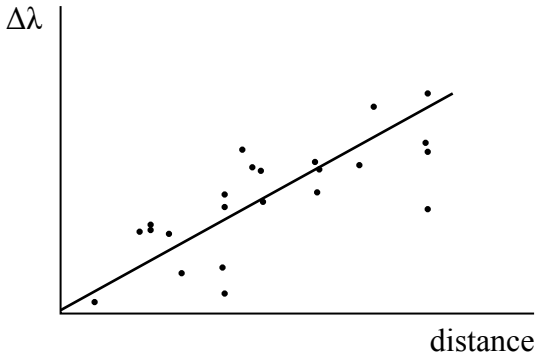

Figure 1

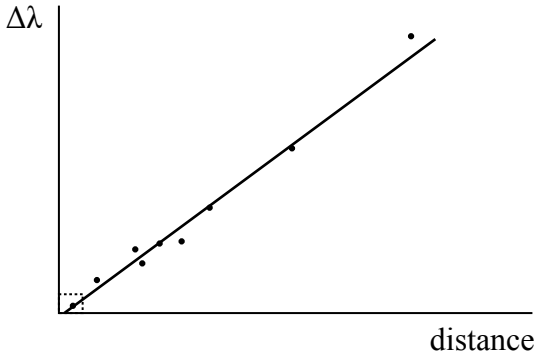

Figure 2

(a) The data used by Hubble for his 1929 plot (Figure 1) is contained within the rectangle close to the origin of the 1931 plot (Figure 2).

Explain how Hubble's observations support the conclusion that the universe is expanding, and assess the reliability of this conclusion on the basis of Hubble's original data.

(5)

(b) The light emitted from a star is due to the energy released by fusion reactions taking place in the core of the star. Our Sun is a main sequence star with a luminosity of 3.85×10^{26} W.
An analysis of the Sun's spectrum gives $\lambda_{max} = 502$ nm

Use the data provided to calculate the radius of the Sun.

(4)

Radius of the Sun = ...

(c) The Sun is believed to be about 4.5 billion years old. To determine this, scientists measure the ratios of the lead isotopes found in meteorites. Since uranium undergoes radioactive decay in a chain to eventually become an isotope of lead, the ratios of lead isotopes can be used to find the age of a meteorite.

(i) $^{238}_{92}U$ decays to $^{206}_{82}Pb$ via the emission of α and β^- radiation.
In the transition of U-238 to Pb-206 eight alpha decays must occur.

State the number of beta decays that must occur. Justify your answer.

(2)

.....

.....

.....

Number of β^- decays = ...

(ii) One isotope produced in the chain is thorium-230, which decays to an isotope of radium with a half-life of 75,000 years.

Calculate the time in years it would take for 90% of an initial sample of thorium to have decayed.

(4)

.....

.....

.....

.....

.....

.....

.....

Time taken = ... years

(Total for Question 20 = 15 marks)

TOTAL FOR PAPER = 90 MARKS

Paper 2 Mark scheme

Question Number	Acceptable answers	Additional guidance	Mark
1	C		**1**
2	C		**1**
3	D		**1**
4	A		**1**
5	C		**1**
6	B		**1**
7	A		**1**
8	C		**1**
9	C		**1**
10	D		**1**

(Total for Multiple Choice Questions = 10 marks)

Question Number	Acceptable answers	Additional guidance	Mark
11 (a)	• The energy equivalent to the mass deficit **(1)** • When nucleons bind together to form an atomic nucleus **(1)**		**2**
11 (b)	• Calculation of mass difference in kg **(1)** • Use of $E = c^2 \Delta m$ **(1)** • $E = 2.77 \times 10^{-11}$ J **(1)**	Example of calculation: (235.0439 + 1.008665) u – (140.9144 + 91.9262+ (3×1.008665)) u = 0.186u (0.1860 u × 1.66 × 10^{-27} kg) × (3 × 10^8 m s^{-1})^2 = 2.77 × 10^{-11} J	**3**

(Total for Question 11 = 5 marks)

Question Number	Acceptable answers	Additional guidance	Mark
12 (a)	• Use of $L = \lambda/2$ **(1)** • Use of $v = f\lambda$ **(1)** • $f = 180$ Hz **(1)**	Example of calculation: $\lambda = 2 \times 0.45$ m $= 0.90$ m $f = v/\lambda = 160$ m s^{-1}/0.9 m $= 178$ Hz	**3**
12 (b)	An explanation that makes reference to: **Either** • The oscillating frame causes the lead spheres to deform plastically **(1)** • And this removes energy from the oscillating frame **(1)** • So the amplitude of oscillations decrease with time as shown by the graph **(1)** **OR** • Spheres collide/vibrate **(1)** • Hence energy dissipated **(1)** • So the amplitude of oscillations decrease with time as shown by the graph **(1)**		**3**

(Total for Question 12 = 6 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>13 *</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
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The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td></td></tr>
</table>

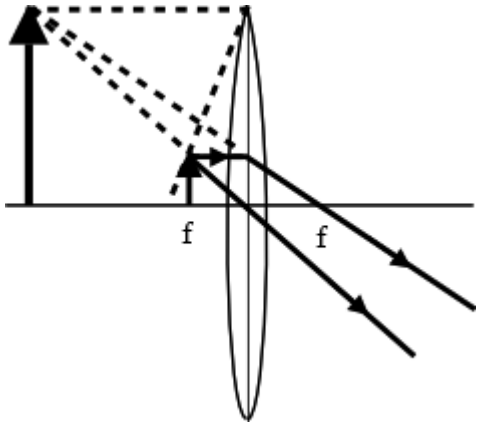
<table>
<tr><th>Question number</th><th>Additional guidance</th><th colspan="2">Mark</th></tr>
<tr><td>13*
(continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.

<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table>
</td><td colspan="2"></td></tr>
</table>

Question Number	Acceptable answers	Additional guidance	Mark
13* (continued)	**Indicative content** • Sound waves incident upon surfaces within the concert hall will be reflected. • Some frequencies will arrive from different directions with a phase difference of (any odd multiple of) π radians **(1) OR** path difference is odd number of half wavelengths • Destructive superposition/interference will occur, causing the waves with those frequencies to be quieter than others. • Other frequencies arrive with a phase difference of zero or (any multiple of) 2π radians **(1) OR** a whole number of wavelengths • Constructive superposition/interference will occur, causing waves with those frequencies to be louder than others. • Problem arises due to reflections from walls, so use absorbing material on surfaces to reduce reflections.		**6**

Question Number	Acceptable answers	Additional guidance	Mark
13* (continued)	**Alternative approach based on standing waves:** • Sound waves incident upon surfaces within the concert hall will be reflected. • Reflections from walls set up standing waves (in room) • Nodes and antinodes are formed for certain frequencies of sound • Nodes are areas of zero/low amplitude so the frequencies of those sound waves will be quieter than others • Antinodes are areas of maximum amplitude so the frequencies of these sound waves will be louder than others • Problem arises due to reflections from walls, so use absorbing material on surfaces to reduce reflections		

(Total for Question 13 = 6 marks)

Question Number	Acceptable answers	Additional guidance	Mark
14 (a)	• Use of $n_1 \sin\theta_1 = n_2 \sin\theta_2$ **(1)** • $c = 67^\circ$ **(1)** • Determines the angle of incidence is 70° **(1)** • so i > c so the ray does totally internally reflect **(1)**	Example of calculation: $1.56 \times \sin c = 1.44 \times \sin 90^o$ $c = 67.4^o$	**4**
14 (b)(i)	Two construction rays from: • ray from tip of object parallel to principal axis drawn then refracted through the focal point **(1)** • ray drawn from tip of object through centre of lens **(1)** • ray drawn from focal point through tip of object and then refracted parallel to the principal axis **(1)** **And** • rays extended back to locate tip of image on the same side as the object **(1)**	Example of diagram:  	**3**

Question Number	Acceptable answers	Additional guidance	Mark
14 (b)(ii)	• Use of $m = v/u$ **(1)** • Use of $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ and substituting for v or u **(1)** • $u = 6.1$ cm **(1)**	Example of calculation: $\frac{v}{u} = -3.5 \quad \therefore v = -3.5u$ $\frac{1}{u} + \frac{1}{-3.5u} = \frac{1}{8.5} \qquad \therefore \frac{3.5-1}{3.5u} = \frac{1}{8.5}$ $\therefore \frac{3.5u}{2.5} = 8.5$ $u = \frac{8.5 \times 2.5}{3.5} = 6.07\,\text{cm}$	**3**

(Total for Question 14 = 10 marks)

Question Number	Acceptable answers	Additional guidance	Mark
15	• Use of $pV = NkT$ **(1)** • Conversion of temperature to Kelvin **(1)** • $p = 95.4$ kPa **(1)** • Calculation of excess pressure **(1)** • Use of $p = F/A$ **(1)** • $\Delta F = 995$ N **(1)** • Sensible comment, e.g. this is a large force so could make the door hard to open **(1)**	Example of calculation: $\frac{p_1}{T_1} = \frac{p_2}{T_2}$ $p_2 = p_1 \times \frac{T_2}{T_1} = 102 \times 10^3\,\text{Pa} \times \frac{(273 + 3.3)\text{K}}{(273 + 22.5)\text{K}}$ $= 95.37 \times 10^3\,\text{Pa}$ $\Delta p = (102 - 95.37)$ kPa $= 6.63$ kPa $\Delta F = A\Delta p = 0.15\,\text{m}^2 \times 6.63 \times 10^3\,\text{Pa} = 994.5\,\text{N}$	**7**

(Total for Question 15 = 7 marks)

Question Number	Acceptable answers	Additional guidance	Mark
16	• Use of $F = k\,\Delta x$ **(1)** • $k = 14.4$ N m^{-1} **(1)** • Use of $T = 2\pi\sqrt{\frac{m}{k}}$ **(1)** • Use of $f = 1/T$ **(1)** • $f = 2.4$ Hz **(1)**	Example of calculation: $k = mg/\Delta x = 66\times 10^{-3}$ kg $\times$ 9.81m s^{-2})/4.5×10^{-2} m = 14.4 N m^{-1} $T = 2\pi(0.066/14.4.0)^{1/2} = 0.425$ s $f=1/T = 1/0.425 = 2.35$ Hz	**5**

(Total for Question 16 = 5 marks)

Question Number	Acceptable answers	Additional guidance	Mark
17 (a)	An explanation that makes reference to: • the temperature is constant when the puree boils because the average kinetic energy of the molecules in the puree is constant. **(1)** • when boiling occurs, the thermal energy supplied increases the potential energy of the molecules causing the molecules to move further apart (producing steam) **(1) OR** when boiling occurs, the thermal energy supplied increases the potential energy of the molecules breaking molecular bonds. **(1)**		**2**
17 (b)	• Use of $\Delta E = mc\Delta\theta$ with a temperature change of 80°C **(1)** • $c = 3.94\times10^{3}\,\text{J kg}^{-1}\,\text{C}^{-1}$ **(1)**	Example of calculation: Temperature rise = $(101 - 21)^{\circ}\text{C}$ $175000\text{J} = 0.444\text{kg}\times c\times(101-21)\text{C}$ $c = 3.94\times10^{3}\,\text{J kg}^{-1}\,\text{C}^{-1}$	**2**
17 (c)	• Use of $\Delta E = m\,L$ **(1)** • Convert peak voltage and current to r.m.s. values (230 V and 8.77 A) **(1) OR** use $P=I_{peak}V_{peak}/2$ **(1)** • Use of $E = VI\,t$ **(1)** • t = 264 s **(1)**	Example of calculation: $\Delta E = m\,L = 0.225\text{kg}\times2.37\times10^{6}\,\text{J kg}^{-1} = 5.33\times10^{5}\,\text{J}$ V = 325 V/√2 = 230 V and I = 12.4 A/√2 = 8.77 A $t = \frac{E}{VI} = \frac{5.33\times10^{5}\,\text{J}}{230\,\text{V}\times8.75\,\text{A}} = 264\text{s}$	**4**

(Total for Question 17 = 8 marks)

<table>
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<tr>
<td>18 (a)*</td>
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<td>6</td>
</tr>
</table>

18 (a)* (continued)

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Question Number	Acceptable answers	Additional guidance	Mark
18 (a)* (continued)	**Indicative content** • a polarising filter restricts the (electric field) vibrations of the (transverse) light wave to a single plane • including the direction of propagation of the light • the light incident on the filter must be plane polarised • when the angle of rotation is a multiple of π rad (including zero), the plane of polarisation of the incident light is perpendicular to the transmission axis of the polarising filter hence the intensity of the transmitted light is zero • when the angle of rotation is an odd multiple of π/2 rad the plane of polarisation of the incident light is the same as that of the transmission axis of the polarising filter hence maximum light is transmitted • the intensity of the transmitted light varies from a minimum to a maximum as the angle of rotation varies as shown by the graph		

Question Number	Acceptable answers	Additional guidance	Mark
18 (a)* (continued)	**Alternative answer** • a polarising filter restricts the (electric field) vibrations of the (transverse) light wave to a single direction • perpendicular to the direction of propagation of the light • the light incident on the filter is plane polarised • when the angle of rotation is a multiple of π rad (including zero), the plane of polarisation of the incident light is perpendicular to the transmission axis of the polarising filter hence the intensity of the transmitted light is zero • when the angle of rotation is an odd multiple of π/2 rad the plane of polarisation of the incident light is the same as that of the transmission axis of the polarising filter hence maximum light is transmitted • the intensity of the transmitted light varies from a minimum to a maximum as the angle of rotation varies as shown by the graph		
18 (b)	• Pass light through one lens of the glasses and view the light through the lens of the second pair of glasses. Rotate one pair of glasses through 90° **(1)** • If the light intensity varies then the glasses use polarising filters **(1)**	Allow full credit for a suitably annotated diagram.	**2**

(Total for Question 18 = 8 marks)

Question Number	Acceptable answers	Additional guidance	Mark
19 (a)(i)	An explanation that makes reference to: • quantisation of energy is the idea that energy is emitted/radiated in discrete packets/photons **(1)** • each photon has an energy which is related to frequency OR suitable reference to $E = hf$ **(1)**		**2**
19 (a)(ii)	• Model A is successful at long wavelengths because the curve for model A follows the experimental curve **(1)** • But model A breaks down for short wavelengths, since it suggests that the intensity tends to infinity as the wavelength gets shorter **(1)** • Model B is successful for short wavelengths because curve B follows the experimental curve **(1)** • But model B indicates higher than expected intensities at larger wavelengths **(1)**		**4**
19 (b)	• Use of $c=f\lambda$ and $E=hf$ **(1)** • Converts eV to J **(1)** • Use of $E = W + KE_{max}$ **(1)** • $KE_{max} = 1.3 \times 10^{-19}$ J **(1)**	Example of calculation: $E = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\,\text{J s}\times3\times10^{8}\,\text{m s}^{-1}}{2.54\times10^{-7}\,\text{m}} = 7.831\times10^{-19}\,\text{J}$ Work function = 6.51×10^{-19} J $E = W + KE_{\max}$ $KE_{\max} = 7.83\times10^{-19}\,\text{J} - 6.51\times10\text{-}19\text{J} = 1.32\times10^{-19}\,\text{J}$	**4**

(Total for Question 19 = 10 marks)

Question Number	Acceptable answers	Additional guidance	Mark
20 (a)	• The wavelength change is bigger the further away the galaxies are **(1)** • The further away galaxies are the faster they are moving, so all distant galaxies are moving away from each other (and the universe is expanding) **(1)** • There is a large amount of scatter in Hubble's original data set. **(1)** • The original data set covers a very small range of distances [only the closest galaxies considered] **(1)** • Hence, on the basis of the original data, the conclusion drawn by Hubble was quite speculative **(1)**		**5**
20 (b)	• Use of $\lambda_{max}T = 2.9\times10^{-3}$ **(1)** • T = 5800 K [accept 5780 K and 6000 K] **(1)** • Use of $L = 4\pi r^2\sigma T^4$ **(1)** • r = 6.9×10^{8} m **(1)**	Example of calculation: $T = \frac{2.9\times10^{-3}\,\text{mK}}{5.02\times10^{-7}\,\text{m}} = 5780\,\text{K}$ $r = \sqrt{\frac{3.85\times10^{26}\,\text{W}}{4\pi\times5.67\times10^{-8}\,\text{Wm}^{-2}\text{K}^{-4}\times(5800\,\text{K})^4}} = 6.91\times10^{8}\,\text{m}$	**4**

Question Number	Acceptable answers	Additional guidance	Mark
20 (c)(i)	• 8 alpha decays reduce the proton number by 16 **(1)** • proton number decreases by only 10, so there must be 6 β decays **(1)** **OR** • balanced equation written for overall decay **(1)** • explicit solution to give 6 β^- decays **(1)**	Example of calculation: $^{238}_{92}\text{U} \rightarrow {}^{206}_{82}\text{Pb} + 8\times{}^{4}_{2}\alpha + \text{N}\times{}^{0}_{-1}\beta^-$ $92 = 82 + (8\times2) - \text{N}$ $92 = 82 + 16 - \text{N}$ $\text{N} = 98 - 92 = 6$ Proof must be given to obtain these marks.	**2**
20 (c)(ii)	• use of $\lambda t_{1/2} = \ln 2$ **(1)** • use of $N = N_0 e^{-\lambda t}$ **(1)** • $\text{N}/\text{N}_0 = 0.1$ **(1)** • $\text{t} = 2.5 \times 10^5$ years **(1)**	Example of calculation: $\lambda = \dfrac{0.693}{75000} = 9.24\times10^{-6}\,\text{y}^{-1}$ $\lambda t = -\ln\left(\dfrac{N}{N_0}\right)$ $\therefore t = \dfrac{-\ln(0.1)}{9.24\times10^{-6}\,\text{y}^{-1}} = 2.49\times10^5\,\text{y}$	**4**

(Total for Question 20 = 15 marks)

Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

Physics

Advanced
Paper 3: General and Practical Principles in Physics

Sample Assessment Materials for first teaching September 2015

Time: 2 hour 30 minutes

Paper Reference **9PH0/03**

You may need the Formulae Sheet, a calculator, protractor and a ruler.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- You may use a scientific calculator.

Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In questions marked with an *****, marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- You are advised to show your working in calculations including units where appropriate.

Turn over ▶

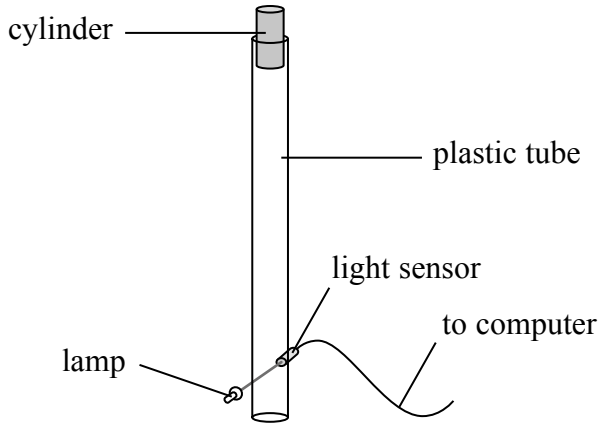
S47560A

S 4 7 5 6 0 A 0 1 3 2

PEARSON

Answer ALL questions in the spaces provided.

1 A student uses a lamp and a light sensor as a light gate connected to a data logger and computer to determine the speed of a falling object. He drops a small cylinder through a clear plastic tube. The light gate and data logger measure the time of fall of the cylinder and the speed is calculated.



The student repeats the experiment five times and records the results in a table.

Speed/m s^{-1}	Mean speed/m s^{-1}
4.52 4.59 4.43 4.63 4.58	4.55

(a) The student incorrectly includes all the values when calculating the mean speed. A second student thinks that the true value of the mean speed is different.

Explain whether the second student is correct.

(2)

(b) Explain **one** advantage of using a light gate and data logger in this experiment.

(2)

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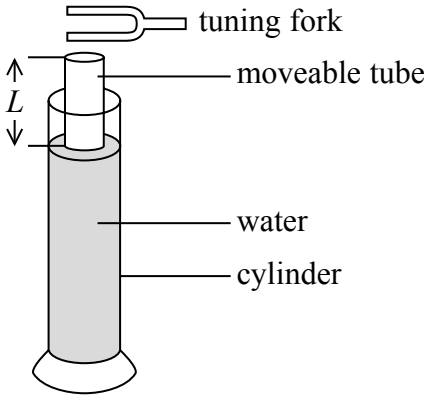
(Total for Question 1 = 4 marks)

2 A set of tuning forks is used to find a value for the speed of sound in air.
A tuning fork is struck and then held near to the end of an air column formed by a moveable tube. The moveable tube is used to adjust the length, L, of the air column until a standing wave is set up in the tube and the loudest sound is heard. The experiment is repeated for a number of different tuning forks.



The following results are obtained by a student.

Fork frequency/Hz	Length, L/cm	Speed of sound/m s^{-1}
256	31.9	327
320	25.6	328
512	16.1	330

Student A says "These results show that the speed of sound increases as the frequency of the sound increases".

Student B says "The speed of sound should be the same for each frequency".

By estimating the uncertainties in these results, conclude which of these statements is valid.

(Total for Question 2 = 4 marks)

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TURN OVER FOR QUESTION 3

3 Small electrical devices are often powered by electric cells; different devices use different types of cell.

(a) The cells normally used in a television remote control have an e.m.f. of 1.5 V.

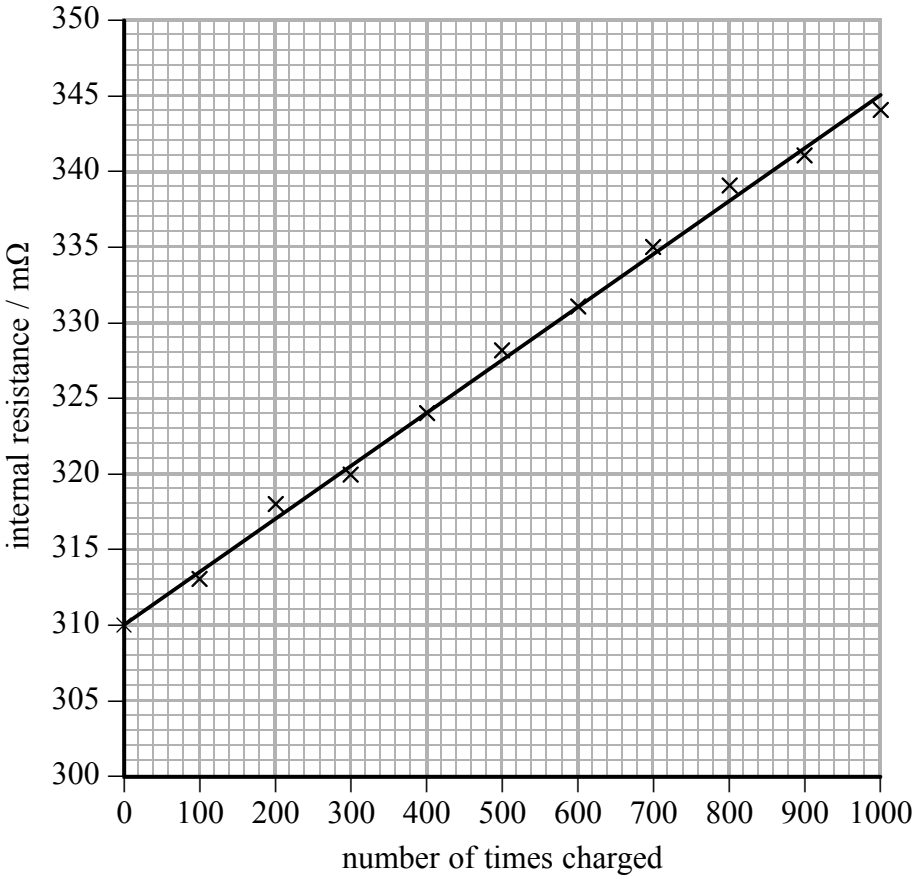
(i) Describe a procedure to determine the internal resistance and e.m.f. of an electrical cell. You should include a circuit diagram.

(3)

(ii) Describe how you would use your results to find a value for the e.m.f. and internal resistance of the cell.

(3)

(b) The cells used in a camera to charge the flash unit are 3.6 V lithium ion rechargeable cells. The data sheet supplied with such a cell includes a graph which shows how the internal resistance of the cell varies with the number of times it has been charged and discharged.



The cell is recommended for use in a camera flash charger which typically draws a supply current of 800 mA. The manufacturer claims that even after 500 charging cycles the cell terminal potential difference (p.d.) will be more than 99% of the terminal p.d. when new and supplying the same current.

Analyse the data from this graph to explain whether it supports the claim, supporting your answer with a calculation.

(4)

(Total for Question 3 = 10 marks)

4 A student carries out an experiment to investigate the stretching of a liquorice lace.

(a) The student fixes one end of the lace to a support and adds different masses to the end of it, measuring the extension each time with a metre rule. His results are shown in the table.

Mass/kg	Force/N	Extension/m
0.03	0.294	0.005
0.04	0.392	0.0075
0.06	0.589	0.011
0.07	0.687	0.012

Criticise the recording of these results.

(3)

(b) Describe how the student should measure the extension of the lace to make his results as accurate as possible.

(2)

.....

.....

.....

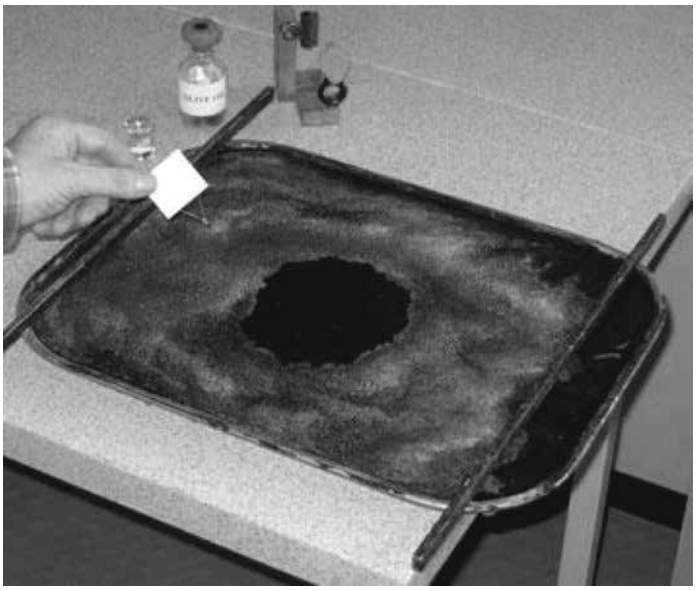
.....

(Total for Question 4 = 5 marks)

5 When a drop of oil is placed on the surface of water it spreads out to form a thin film 1 molecule thick. A student uses this phenomenon to determine the size of an oil molecule.

She dips a wire loop into the oil so that a small, spherical oil drop forms. She uses a millimetre scale to measure the diameter of this oil drop.

The student fills a tray with water and scatters a fine powder on the water surface. The oil drop is placed on the water surface and spreads out to form a thin film, approximately circular, as shown in the photograph.



The student uses a metre rule to measure the diameter of the circular thin film. She records the following measurements:

diameter of oil drop = 0.5 mm
diameter of thin film = 250 mm

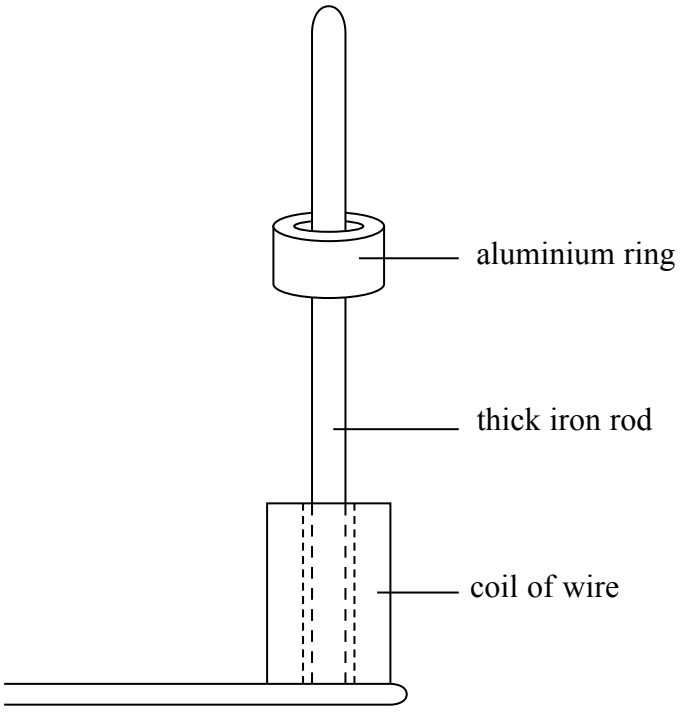
The student now equates the volume of oil as a drop to the volume of the film.

Evaluate the student's method and suggest refinements that would improve the accuracy of determining the size of the molecule.

(Total for Question 5 = 6 marks)

6 A coil of wire is placed around the lower end of an iron rod. The coil is supplied with an alternating current.

A thick aluminium ring is placed around the iron rod above the coil. The coil remains in the position shown.



(a) An alternating current is induced in the aluminium ring.

Explain, using Lenz's law, why the aluminium ring remains in the position shown.

(4)

(b) The current is switched off and the aluminium ring comes to rest on top of the coil. The supply to the coil is changed and a direct current (dc) is switched on. An upwards force F acts on the ring for 0.05 s accelerating it to a final speed, v. The ring then moves freely through a height of 30 cm.

Mean diameter of ring = 4.8 cm
Mass of ring = 0.019 kg
Magnetic field strength = 0.032 T

(i) Use conservation of energy to calculate the speed v of the ring after 0.05 s.

(2)

v = ...

(ii) Use the idea of impulse to calculate the magnitude of the mean force F acting on the ring and hence the mean current I in the ring.

(6)

F = ...

I = ...

(Total for Question 6 = 12 marks)

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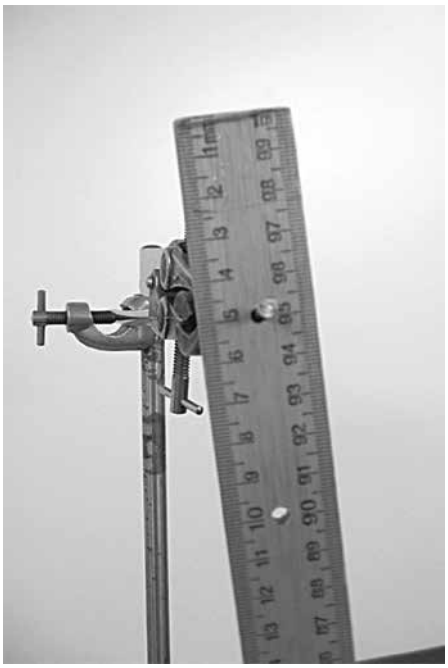
7 A metre rule has a small hole drilled at the 5 cm mark. The rule is hung on a horizontal pin passing through the hole.



(a) The rule is rotated through a small angle and released. It then oscillates about the pin as a pendulum with a time period T.

(i) Describe how to use a stopwatch to determine a value for T.

(2)

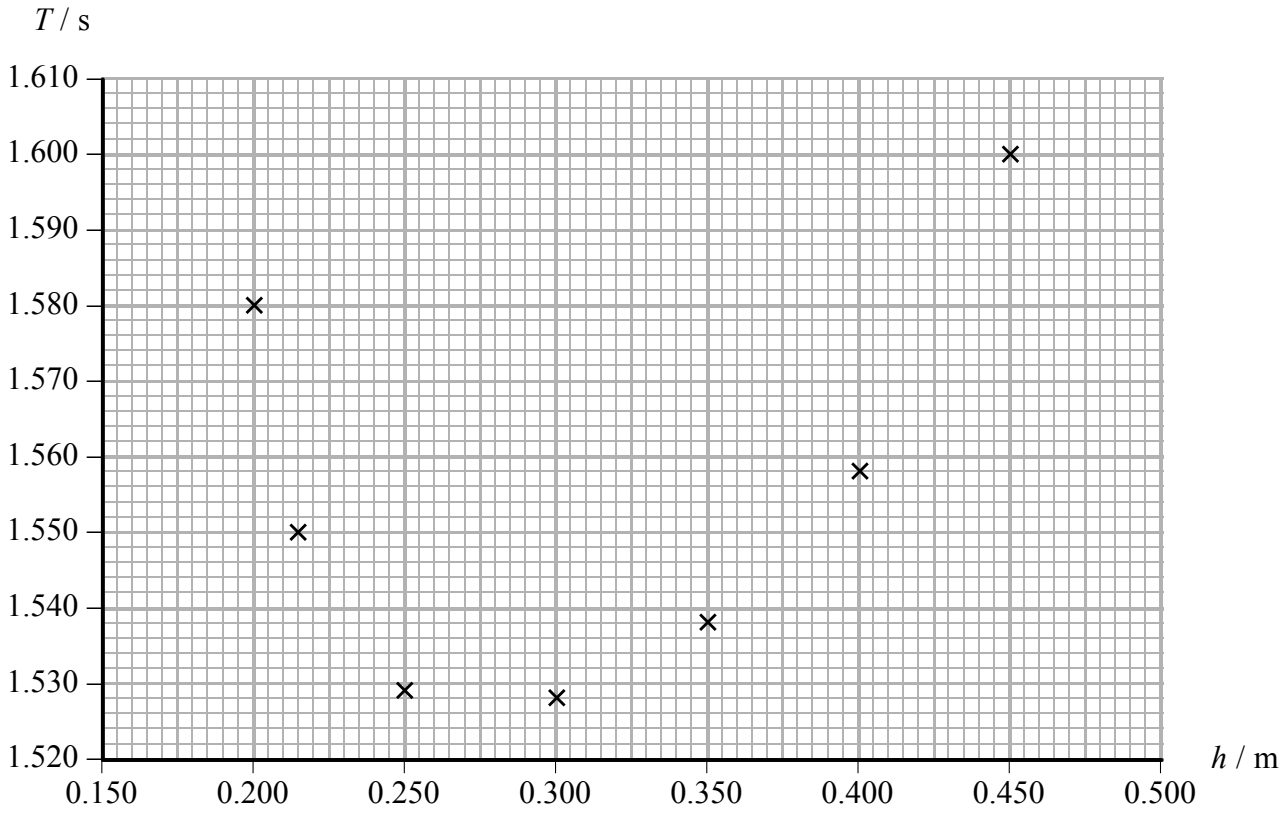
(ii) State **two** reasons why repeating the readings will improve the results for T.

(2)

(b) There are six more holes drilled at intervals down the rule. The rule is hung from each hole and the distance h from the pin to the 50 cm mark is recorded.

T is determined for each value of h and a graph of T against h is plotted.

h/m	T/s
0.450	1.601
0.400	1.558
0.350	1.538
0.300	1.528
0.250	1.529
0.215	1.550
0.200	1.580



(i) Draw a line of best fit on the graph.

(1)

(ii) Use your line to determine the value of h that would produce the smallest value of T.

Record these values.

(2)

h = ... T = ...

(c) The graph of T against h does **not** produce a straight line.

The variables T and h are related by

$$T^2 h = 4\pi^2 h^2/g + C$$

where C is a constant.

Describe a graphical method to determine a value for C and state the unit for C.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 7 = 10 marks)

8 Photograph 1 shows a toy known as a popper. It is a hollow hemisphere made of rubber.

Photograph 1

When the top of the popper is pushed down, it changes shape as in Photograph 2.

Photograph 2

It remains in this shape for two to three seconds. It then returns to its original shape and is launched from the surface, rising nearly a metre.

(a) A student concludes that the material of the popper should be classed as a plastic material rather than an elastic material because it remains inverted.

Explain whether you think this conclusion is correct.

(3)

(b) The initial speed of the popper can be determined using only a metre rule to measure the maximum height reached by the popper.

(i) Describe how the maximum height measurement can be used to determine the launch speed.

(3)

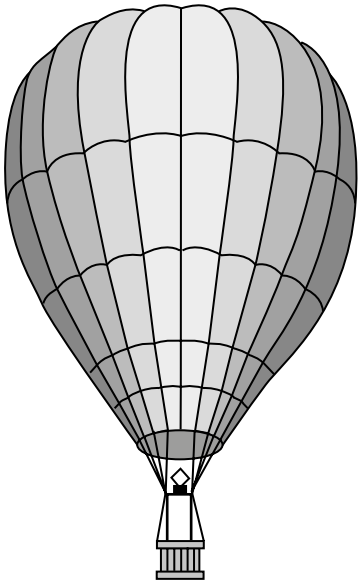
(ii) Comment on using the maximum height measurement as a means of determining an accurate value for the launch speed.

(3)

(Total for Question 8 = 9 marks)

9 Newton's laws relate the changes in motion of an object to the forces acting on the object.

(a) A hot-air balloon is made of an envelope, containing hot air, with a wicker basket suspended from it. The balloon rises upwards because the heated air in the envelope is less dense than the surrounding air.



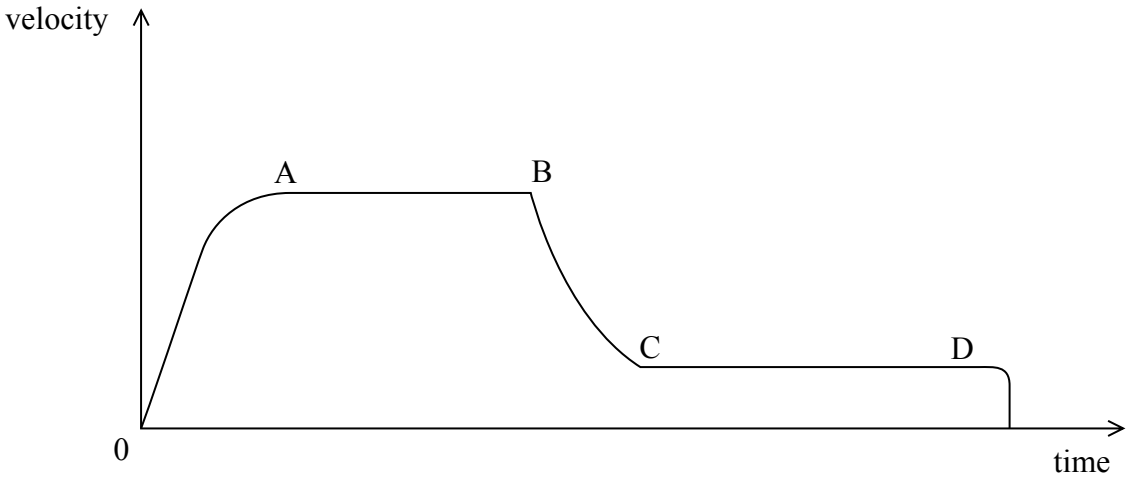
The total volume of the hot-air balloon is 2880 m^3. The total mass of the hot-air balloon, including the envelope, is 3400 kg. The density of the surrounding air is 1.20 kg m^{-3}.

Calculate the initial upward acceleration of the balloon.

(4)

Initial acceleration = ...

*(b) The graph shows the velocity of a skydiver from the moment that she begins her freefall jump, until she lands on the ground.

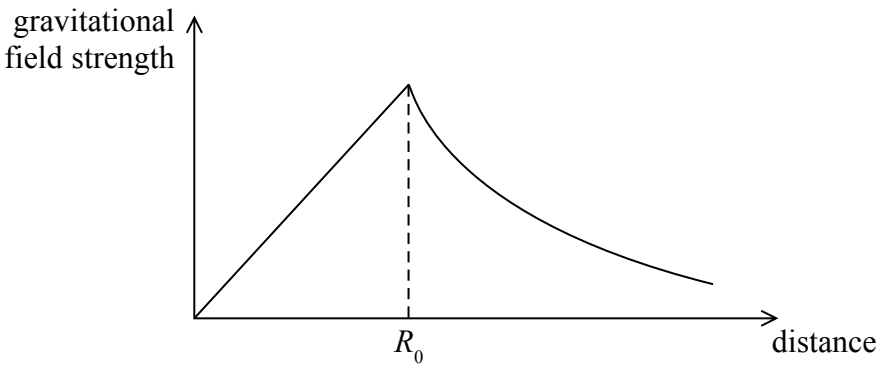


Explain, in terms of the force acting, the shape of the graph from the point when the parachute opens until point D.

(6)

(Total for Question 9 = 10 marks)

10 The graph shows the variation of the gravitational field strength with distance from the centre of the Earth. R_0 is the radius of the Earth.



(a) Describe how gravitational field strength varies with distance from the centre of the Earth

- for distances between 0 and R_0
- for distances greater than R_0

(3)

(b) A scientist suggests the following:

> "If a tunnel were made through the centre of the Earth, an object dropped at one end would accelerate downwards until it reached the centre. It would then decrease in speed until it reached the other end of the tunnel with a speed of zero. The object would then return the other way, undergoing simple harmonic motion."

Using the graph between 0 and R_0, determine whether simple harmonic motion would occur.

(4)

(c) The scientist also suggests that the period of oscillation for a body dropped through the tunnel would be the same as the orbital period for a body orbiting just above the surface of the Earth. Its radius of orbit is assumed to be R_0.

(i) Derive an expression for the period of oscillation of the body dropped through the tunnel.

(4)

(ii) Derive an expression for the orbital period for a body that is orbiting the Earth with radius R_0.

(3)

(Total for Question 10 = 14 marks)

11 A physicist investigates how light intensity varies with distance from a light bulb. She sets up the apparatus as shown.

(a) Explain why the resistance R of the LDR will increase as it gets further away from the bulb.

(2)

(b) The relationship between R and d is given by

$$R = \mathrm{k}\, d^{\,\mathrm{p}}$$

where k and p are constants.

Explain why a graph of ln R against ln d should give a straight line.

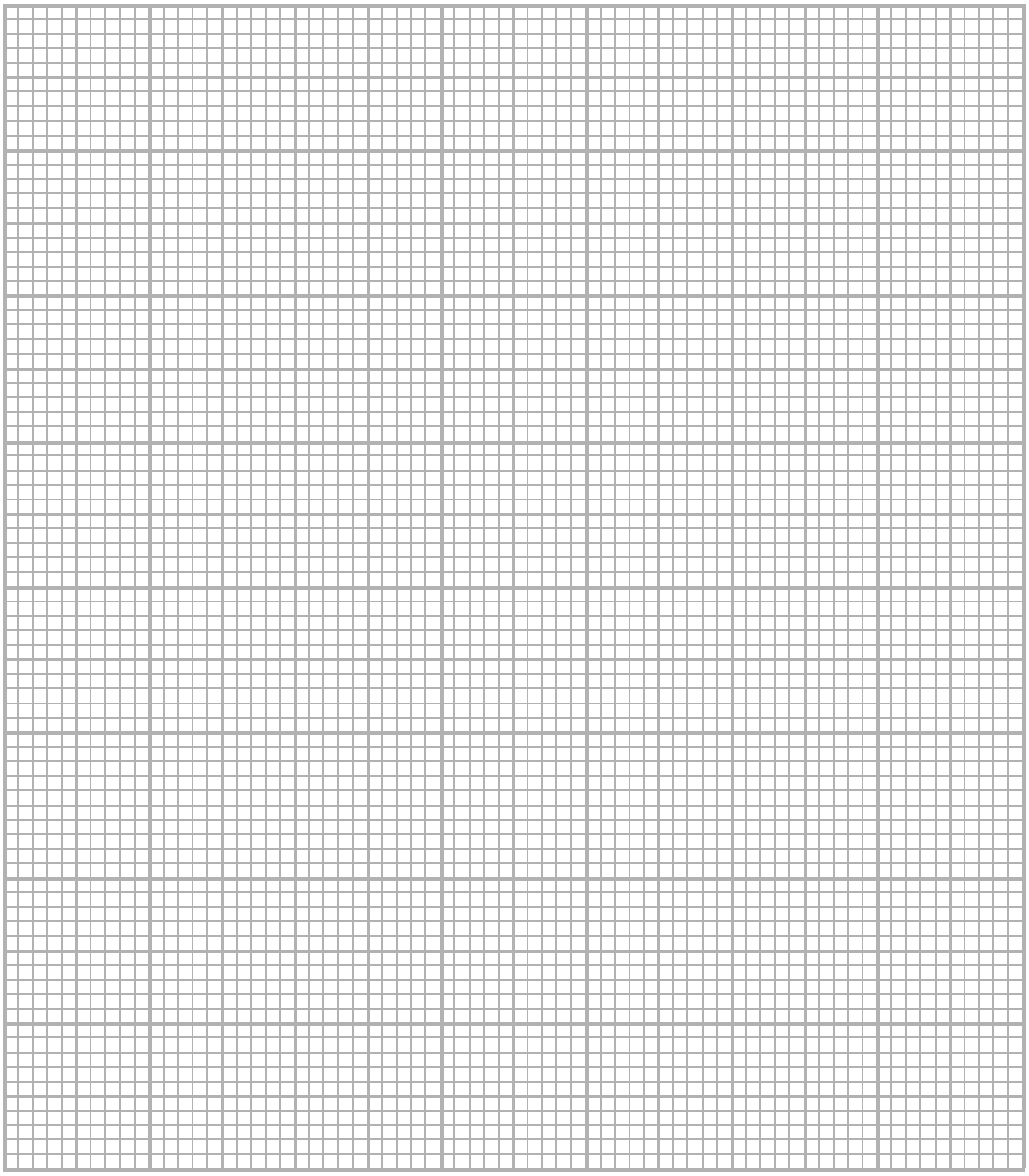
(2)

(c) She measures R for different values of d and records the following results.

d/m	R/kΩ		
1.00	1.79		
1.20	2.24		
1.60	3.32		
2.00	4.04		
2.60	5.50		

(i) Plot a graph of ln R against ln d. Use the columns provided to show any processed data.

(5)



(ii) Determine the mathematical relationship between R and d.

(4)

(Total for Question 11 = 13 marks)

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TURN OVER FOR QUESTION 12

12 A simple model of the hydrogen atom consists of an electron moving in a circular path around a proton.

(a) (i) In this simple model it is the electrostatic force, rather than the gravitational force, that is responsible for keeping the electron in a circular path.

By means of calculations justify this statement.

radius r of the hydrogen atom = 5.3×10^{-11} m

(4)

(ii) Ignoring the gravitational force, calculate the velocity of the electron in this simple model of the hydrogen atom.

(3)

Velocity = ...

(b) In another model it is assumed that the electron behaves like a wave with a de Broglie wavelength λ. The wave associated with the electron forms a standing wave whose wavelength is equal to the circumference of the circular path.

Calculate the velocity of the electron based on this model.

(3)

Velocity = ...

(Total for Question 12 = 10 marks)

13 The photograph shows a tea cup on a saucer.

A student notices that walking with this sort of tea cup when it is filled with tea is particularly difficult to do without spilling it.

While walking, the tea starts to oscillate from side to side in the cup, rapidly increasing in amplitude and spilling over the edge.

The student develops the hypothesis that spillage occurs most when the frequency of the steps taken by a person matches the natural frequency of oscillation of tea in the cup.

(a) Explain whether the student's hypothesis is supported by relevant physics.

(4)

*(b) (i) Devise an experiment to investigate the hypothesis.

(6)

(ii) Describe how the measurements taken will be used to come to a conclusion.

(3)

(Total for Question 13 = 13 marks)

TOTAL FOR PAPER = 120 MARKS

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Paper 3 Mark scheme

Question number	Acceptable answers	Additional guidance	Mark
1(a)	An explanation that makes reference to the following points: • Comment on the data **(1)** • Correct consequent conclusion **(1)**	4.43 is an anomalous value So the mean value is too low Accept data is concordant so mean value is correct	**2**
1(b)	An explanation that makes reference to the following points: • Light gates can record short times accurately **(1)** **OR** with smaller uncertainty **(1)** • Because human reaction time is not involved **(1)**		**2**

(Total for Question 1 = 4 marks)

Question number	Acceptable answers	Additional guidance	Mark
2	• Sensible estimate of uncertainties from readings given **(1)** • Adds percentage uncertainties **(1)** • Hence calculates uncertainty in speed **(1)** • Candidate's conclusion must be supported by their estimate of the uncertainties **(1)**	Example of calculation: %U in L is (0.1/25.6) x 100 % = 0.4 % %U in F is (1/320) x 100 % = 0.3 % %U in speed is 0.7 % 328 x 0.007 = 2 Speed = 328 ± 2 All three results are within the calculated uncertainty so concludes student B is correct	**4**

(Total for Question 2 = 4 marks)

Question number	Acceptable answers	Additional guidance	Mark
3 (a)(i)	A description that makes reference to the following points: Circuit diagram showing: • Cell, variable resistor and ammeter in series and voltmeter in parallel with cell **(1)** • Recording pairs of readings of terminal p.d. and current **(1)** • Use the variable resistor to obtain 5 other pairs of readings **(1)**	Should be between 5 and 10 other pairs	**3**
3 (a)(ii)	A description that makes reference to the following points: • Plot a graph of terminal potential difference on the y-axis and current on the x-axis **(1)** • Intercept on the y-axis equals e.m.f. **(1)** • And gradient = -r **(1)**		**3**
3(b)	• From graph: after 500 charging cycles internal resistance of cell is 327 mΩ **(1)** • Use of $V = \varepsilon - Ir$ **(1)** • Use of $\frac{V_{500}}{V_0} \times 100\%$ $\frac{V_{500}}{V_0} \times 100\% = 99.6\%$ **(1)** • So manufacturer's claim is correct **(1)**	Example of calculation: $V_0 = 3.6\,\text{V} - 0.800\,\text{A} \times 0.310\,\Omega$ $= 3.6\,\text{V} - 0.248\,\text{V} = 3.352\,\text{V}$ $V_{500} = 3.6\,\text{V} - 0.800\,\text{A} \times 0.327\,\Omega$ $= 3.6\,\text{V} - 0.262\,\text{V} = 3.338\,\text{V}$ $\frac{V_{500}}{V_0} \times 100\% = \frac{3.338\,\text{V}}{3.352\,\text{V}} \times 100\% = 99.6\%$ This last mark is awarded only if the conclusion is correctly supported by the calculation.	**4**

(Total for Question 3 = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
4 (a)	Any three from: • Inconsistent precision for extension **(1)** • Lack of precision on mass, should be shown to 3 DP **(1)** • No evidence of repeat readings **(1) OR** there should be more readings to compensate for repeat readings being inappropriate **(1)** • Inconsistent intervals between readings **(1)**	Uncertainty suggested by 1 sf is far greater than that expected in practice	**3**
4 (b)	A description that makes reference to two of the following points: • use of ficidual mark **(1)** • eye close to liquorice lace to avoid parallax errors **(1)** • Fixed metre rule close to lace **(1)** • Use of set square to ensure rule vertical **(1)**		**2**

(Total for Question 4 = 5 marks)

Question number	Acceptable answers	Additional guidance	Mark
5	• Diameter is only half a division on the scale **(1) OR** diameter is measured to only 1 sf **(1)** • Hence there is a large percentage uncertainty in measurement of diameter of oil drop **(1)** • Since the volume of the drop is calculated by taking (diameter)^3, the percentage uncertainty in volume becomes very large (3 × % uncertainty in diameter) **(1)** • Suggestion for improvement: use a larger oil drop, use a (vernier) scale capable of reading to nearest 0.1 mm, project image of droplet to larger size **(1)** • Drop will not spread out as an exactly circular area, so diameter reading may be inaccurate **(1)** • Suggestion for improvement: the diameter of spread-out oil drop should be taken a number of times across a number of different directions and a mean calculated **(1)**	Allow for identification of any other valid problems and improvements based on good physics, for example place metre rule across tray so that it is close to the surface.	**6**

(Total for Question 5 = 6 marks)

Question number	Acceptable answers	Additional guidance	Mark
6 (a)	An explanation that makes reference to the following points: • The current produces a magnetic field around the aluminium ring **(1)** • The direction of the ring field opposes the change producing it **(1)** • The fields repel, producing a force **(1)** • The electromagnetic force is equal and opposite to the weight of the ring so it remains in position shown **(1)**		**4**
6 (b)(i)	• Use of ½ $mv^2 = mgh$ **(1)** • $v = 2.43$ m s^{-1} **(1)**	Example of calculation: $v = \sqrt{2gh} = \sqrt{2\times9.81\times0.30} = 2.43$ m s^{-1}	**2**
6 (b)(ii)	• Use of impulse = change in momentum **(1)** • Recognises initial velocity is zero **(1)** • Hence $F = 0.923$ N **(1)** • Use of $l = \pi d$ **(1)** • Equates calculated value of F with BIl **(1)** • Hence I = 191 A **(1)**	Example of calculation: $Ft = mv - mu$ where $u = 0$ So $F = (0.019\text{ kg} \times 2.43\text{ m s}^{-1})/0.05\text{ s} = 0.923$ N $l = \pi \times 0.048\text{ m} = 0.151$ m $I = 0.923\text{ N}/(0.032\text{ T} \times 0.151\text{ m}) = 191$ A	**6**

(Total for Question 6 = 12 marks)

Question number	Acceptable answers	Additional guidance	Mark
7 (a)(i)	A description that makes reference to the following points: • Record nT (where n is at least 5) **(1)** • Divide measurement by n **(1)**		**2**
7 (a)(ii)	• Anomalies can be spotted **(1)** • Reduce the effect of random error **(1)**		**2**
7 (b)(i)	• BFL is smooth and thin with a definite minimum and minimum is in range 0.26 m – 0.28 m **(1)**		**1**
7 (b)(ii)	• Values read correctly from candidate's line **(1)** • h to 3 sig fig **and** T to 4 sf **(1)**	Values from their curve to within 1 small square with no unit penalty.	**2**
7 (c)	A description that makes reference to the following points: • Plot $T^2 h$ against h^2 **(1)** • C is intercept on $T^2 h$ axis **(1)** **OR** C is the value of $T^2 h$ when h^2 is zero **(1)** • Unit is m s^2 **(1)**		**3**

(Total for Question 7 = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
8 (a)	An explanation that the student's conclusion is incorrect because: • The popper returns to its original shape, even though there is a time delay **(1)** • Elastic material returns to its original shape when the deforming force is removed **(1)** • But a plastic material would suffer a permanent deformation **(1)**		**3**
8 (b)	A description that makes reference to the following points: • Refer to $v^2 = u^2 + 2as$ **(1)** • Where s is height reached, v is zero, $a = -g$ **(1)** • So $u = \sqrt{2gs}$ **(1)**	Allow argument $\frac{1}{2} mv^2 = mgh$ to get the same results.	**3**
8 (b)(ii)	• Air resistance will act on the popper… **(1)** • …As a decelerating force **(1) OR**… dissipating energy **(1)** • So the initial speed will be lower than in the absence of air resistance, so the suggestion is not correct **(1)**		**3**

(Total for Question 8 = 9 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>9 (a)</td><td>• Uses weight of displaced air = ρVg (1)
• Finds resultant force = upthrust – weight (1)
• Uses F = ma to find acceleration (1)
• Acceleration = 0.161 m s^{-2} (1)</td><td>Example of calculation:
Weight of air displaced = ρVg = 1.20 kg m^{-3}×2880 m^3× 9.81m s^{-2} = 33 903N
Resultant upward force = 33 903 N – (3400 kg × 9.81m s^{-2}) = 549 N
Acceleration = 549 N/3400 kg = 0.161 m s^{-2}</td><td>4</td></tr>
<tr><td>9 (b)*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5–4</td><td>3</td></tr><tr><td>3–2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table></td><td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>9 (b)*
(continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td></td><td></td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
9 (b)* (continued)	**Indicative content** • As parachute opens (at B) the upwards force increases • Along BC the velocity is decreasing at a non-constant rate • The drag is greater than weight (negative gradient) • The drag is decreasing (curved line) • Eventually the drag force balances the weight • No acceleration so line is horizontal		

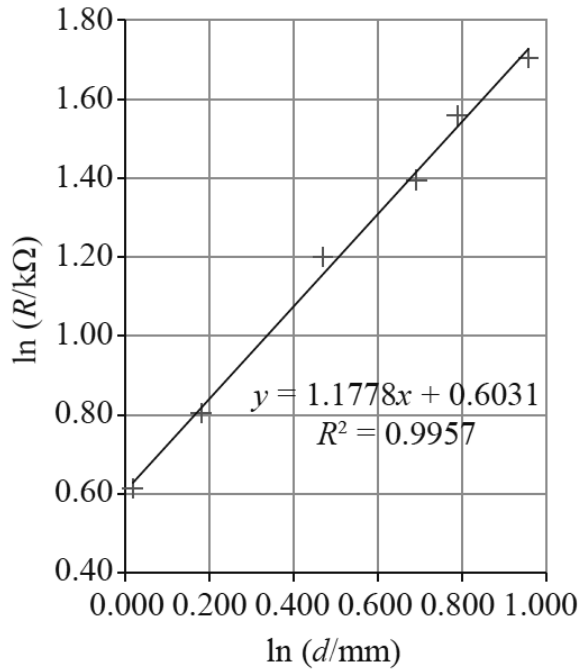
(Total for Question 9 = 10 marks)

Question number	Acceptable answers	Additional guidance	Mark
10 (a)	A description that makes reference to the following points: • g is directly proportional to r up to R_0 **(1)** • and then g decreases with increasing r **(1)** • where g is proportional to the inverse of the square of r **(1)**		**3**
10 (b)	• Force on object = *mg* (local *g*) **(1)** • Force is proportional to displacement **(1)** • Force acts in the opposite direction to the displacement **(1)** • Therefore we can say $F = -kx$, so the condition for SHM is met and the prediction is correct **(1)**		**4**
10 (c)(i)	**Either** • When $x = R_0$, $F = GMm/R_0^2$ **(1)** • $F = GMmR_0/R_0^3$ so $k = m\omega^2 = GMm/R_0^3$ **(1)** • Use of $T=2\pi/\omega$ **(1)** • $T^2 = 4\pi^2/\omega^2 = 4\pi^2 R_0^3/GM$ So $T = 2\pi\sqrt{(R_o^3/GM)}$ **(1)** **OR** • From graph $F=-(g/R_o)r$ **(1)** • From which $\omega = \sqrt{(g/R_0)}$ **(1)** • Use of $T=2\pi/\omega$ **(1)** • So $T = 2\pi\sqrt{(R_o/g)}$ **(1)**		**4**

Question number	Acceptable answers	Additional guidance	Mark
10 (c)(ii)	**Either** Centripetal force = $mv^2/R_0 = GMm/R_0^2$ **(1)** • $4\pi^2 R_0^2/ T^2R_0 = GM/R_0^2$ **(1)** • $T^2 = 4\pi^2/\omega^2 = 4\pi^2 R_0^3/GM$ So $T = 2\pi\sqrt{(R_o^3/GM)}$ **(1)** **OR** • $mg = mv^2/R_0 = m\,\omega^2R_0$ **(1)** • So $\omega = \sqrt{(g/R_0)}$ **(1)** • $T = 2\pi/\omega = 2\pi\sqrt{(R_0/g)}$ **(1)**		**3**

(Total for Question 10 = 14 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>11 (a)</td><td>An explanation that makes reference to the following points:
• Resistance increases with decreasing intensity (1)
• As distance increases light intensity decreases so resistance increases (1)</td><td></td><td>2</td></tr>
<tr><td>11 (b)</td><td>An explanation that makes reference to the following points:
• Shows expansion ln R = p ln(d) + ln(k) (1)
• Compares with y = mx+ c and states that the gradient is p which is constant (1)</td><td></td><td>2</td></tr>
<tr><td>11 (c)(i)</td><td>• Ln values correct and to 3 or 4 SF (1)
<table>
<tr><th>d/m</th><th>R/kΩ</th><th>ln (d/m)</th><th>ln (R/kΩ)</th></tr>
<tr><td>1.00</td><td>1.79</td><td>0.000</td><td>0.582</td></tr>
<tr><td>1.20</td><td>2.24</td><td>0.182</td><td>0.806</td></tr>
<tr><td>1.60</td><td>3.32</td><td>0.470</td><td>1.200</td></tr>
<tr><td>2.00</td><td>4.04</td><td>0.693</td><td>1.396</td></tr>
<tr><td>2.20</td><td>4.70</td><td>0.788</td><td>1.548</td></tr>
<tr><td>2.60</td><td>5.50</td><td>0.956</td><td>1.705</td></tr>
</table>
• Labels and unit (1)
• Scales (1)
• Plots (1)
• Line of best fit (1)</td><td>See marking guidance for graph plotting</td><td>5</td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
11 (c)(i) (continued)			
11 (c) (ii)	• Finds gradient with large triangle – at least half the plotted length **(1)** • 1.13 < p < 1.23 to 2/3 SF and no units **(1)** • Obtains $k = 1.8$ **(1)** • States relationship between R and d **(1)**		**4**

(Total for Question 11 = 13 marks)

Question number	Acceptable answers	Additional guidance	Mark
12 (a)(i)	• use of $F = Q_1Q_2/4\pi\varepsilon_0 r^2$ **(1)** • use of $F = Gm_1m_2/r^2$ **(1)** • Expresses forces as a ratio **(1) OR** calculates the individual forces F_e=8.1 x 10^{-8} N F_g = 3.6 x 10^{-47} N **(1)** • Ratio = 2 x 10^{39} or 5 x 10^{-40} and identifies gravitational force as insignificant **(1)**		**4**
12 (a)(ii)	• use of $F = mv^2/r$ and $F = Q_1Q_2/4\pi\varepsilon_0 r^2$ **(1)** • to derive $v = \sqrt{\frac{Q_1Q_2}{4\pi\epsilon_0 rm}}$ **(1)** • velocity = 2.2× 10^6 m s^{-1} **(1)**	Example of calculation: $v = \sqrt{\frac{Q_1Q_2}{4\pi\epsilon_0 rm}}$ $v = \sqrt{\frac{1.6\times10^{-19}\text{ C}\times1.6\times10^{-19}\text{ C}}{4\pi\times8.85^{-12}\text{ F}m^{-1}\times5.3\times10^{-11}\text{m}\times9.1\times10^{-31}\text{ kg}}}$ v = 2.185 × 10^6 m s^{-1}	**3**
12 (b)	• Calculates wavelength λ (circumference) **(1)** • Use of $p = h/\lambda$ **(1)** • v = 2.2 × 10^6 m s^{-1} **(1)**	Example of calculation: $\lambda = 2\pi r = 2\pi \times 5.3 \times 10^{-11}$m = 3.33 × 10^{-10} m $\lambda = h/mv$ so $v = h/m$. $v = 6.63\times10^{-34}$ J s/(9.1×10^{-31} kg×3.33×10^{-10} m) v = 2.188 × 10^6 m s^{-1}	**3**

(Total for Question 12 = 10 marks)

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>13 (a)</td><td>An explanation that makes reference to the following points:
• Resonance is occurring… (1)
• …when the driving frequency/forced vibration (at walking frequency) matches the natural frequency … (1)
• …energy transfer is maximum (1)
• Supporting the observation that the amplitude rapidly increases (1)</td><td></td><td>4</td></tr>
<tr><td>13 (b)(i)*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table><tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr><tr><td>6</td><td>4</td></tr><tr><td>5–4</td><td>3</td></tr><tr><td>3–2</td><td>2</td></tr><tr><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td></tr></table></td><td>Guidance on how the mark scheme should be applied:

The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).

If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>13 (b)(i)* (continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td></td><td></td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
13 (b)(i)* (continued)	**Indicative content** • Determine the natural frequency by displacing the tea in the cup and measuring the time for oscillations • Time (5 to 10 or 'suitable number' if test run mentioned) full oscillations and divide by the number • Carry the tea for a known volume of tea for fixed number of steps at a steady pace • Determine the frequency of the gait • Measure the quantity of tea remaining • Repeat for other walking paces		
13 (b)(ii)	A description that makes reference to the following points: • Plot volume of remaining tea against walking frequency **(1)** • Determine whether there is a relationship between step frequency and spillage **(1)** • If there is, determine whether maximum spillage occurs at or near the natural frequency **(1)**		**3**

(Total for Question 13 = 13 marks)

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