

Write your name here

Surname

Other names

Pearson Edexcel
International
Advanced Level

Centre Number

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Candidate Number

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Physics

Advanced

Unit 4: Physics on the Move

Monday 9 January 2017 – Afternoon

Time: 1 hour 35 minutes

Paper Reference

WPH04/01

You must have:

Ruler and protractor

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.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
– *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

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.

Turn over ►

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Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☐.
If you change your mind, put a line through the box ☐ and then
mark your new answer with a cross ☐.

1 Which of the following is **not** a fundamental particle?

- ☐ A electron
- ☐ B neutrino
- ☐ C pion
- ☐ D quark

(Total for Question 1 = 1 mark)

2 Which of the following could be a correct unit for magnetic flux density?

- ☐ A N C^{-1}
- ☐ B N kg^{-1}
- ☐ C $\text{N A}^{-1} \text{m}^{-1}$
- ☐ D N C m s^{-1}

(Total for Question 2 = 1 mark)

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Questions 3 and 4 refer to the following situation.

A toy aeroplane is being spun around on the end of a piece of string.

3 Which of the following changes would require an increase in the tension in the string?

- ☐ A decreasing the angular velocity of the toy aeroplane
- ☐ B decreasing the mass of the toy aeroplane
- ☐ C decreasing the period of rotation of the toy aeroplane
- ☐ D decreasing the speed of the toy aeroplane

(Total for Question 3 = 1 mark)

4 The toy aeroplane makes 14 full revolutions in 6 s.

Which of the following gives the angular velocity of the toy aeroplane in rad s^{-1} ?

- ☐ A $\frac{14 \times \pi}{6}$
- ☐ B $\frac{14 \times 2\pi}{6}$
- ☐ C $\frac{6 \times \pi}{14}$
- ☐ D $\frac{6 \times 2\pi}{14}$

(Total for Question 4 = 1 mark)

5 In the early 20th century experiments were carried out to measure the scattering of alpha particles after striking thin gold foil.

Which of the following could **not** be concluded from the results of these experiments?

- ☐ A The nucleus contains most of the mass of the atom.
- ☐ B The nucleus is made of protons and neutrons.
- ☐ C The nucleus is charged.
- ☐ D The nucleus has a much smaller radius than the radius of the atom.

(Total for Question 5 = 1 mark)



- 6 A kaon decays into a pion and two leptons.

Which of the following decays is possible?

- ☐ A $K^0 \rightarrow \pi^- + \mu^+ + \nu_\mu$
- ☐ B $K^- \rightarrow \pi^- + e^- + \nu_e$
- ☐ C $K^+ \rightarrow \pi^0 + \mu^+ + \nu_e$
- ☐ D $K^- \rightarrow \pi^0 + e^- + \nu_\mu$

(Total for Question 6 = 1 mark)

- 7 $^{14}_6\text{C}$ is an isotope of carbon.

Which row of the table correctly shows the number of neutrons and the number of protons in a nucleus of $^{14}_6\text{C}$?

	Number of neutrons	Number of protons
☐ A	6	8
☐ B	14	8
☐ C	8	6
☐ D	14	6

(Total for Question 7 = 1 mark)

- 8 In a linear accelerator, successive drift tubes increase in length.

Which of the following is the correct reason for the increase in length?

- ☐ A The time spent by the particles in successive tubes increases.
- ☐ B The time spent by the particles in successive tubes stays the same.
- ☐ C The particles gain more energy in successive tubes.
- ☐ D The frequency of the accelerating voltage can be increased.

(Total for Question 8 = 1 mark)



- 9 A ball of mass m with velocity v strikes a wall perpendicularly and bounces off with the same speed in the opposite direction. The collision takes time t .

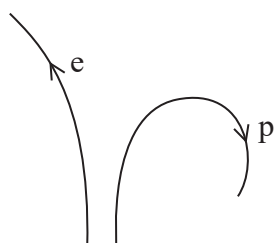
Which of the following is the mean force acting on the ball during the collision?

- ☐ A mv/t
☐ B $2mv/t$
☐ C $-mv/t$
☐ D $-2mv/t$

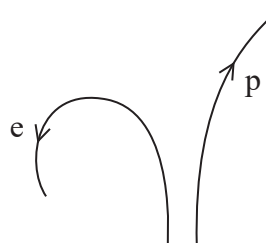
(Total for Question 9 = 1 mark)

- 10 A proton p and an electron e , with the same velocity, enter a magnetic field which is perpendicular to the direction of their motion. The field acts into the page.

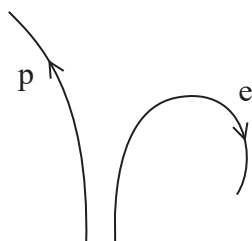
Which of the following diagrams best represents the motion of the particles?



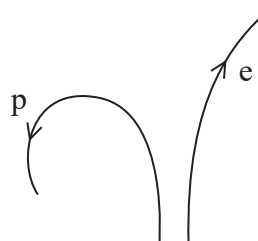
☐ A



☐ B



☐ C



☐ D

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS



SECTION B

Answer ALL questions in the spaces provided.

- 11 A teacher states ‘the repulsive force between 1 C of charge on the ground and 1 C of charge on a 1000 kg mass is large enough to support the mass when it is 1 km above the ground’.

Determine whether the teacher is correct.

(4)

(Total for Question 11 = 4 marks)

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12 The wavelength associated with a moving particle, known as the de Broglie wavelength, depends on the momentum of the particle.

- (a) Show that momentum and kinetic energy are related by the equation $E_k = p^2/2m$ (2)

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- (b) Hence determine the de Broglie wavelength for a proton with kinetic energy 18.8 keV. (4)

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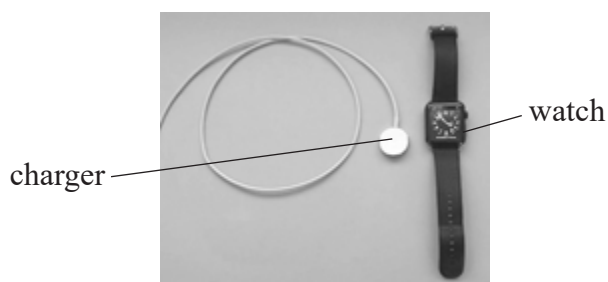
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de Broglie wavelength = ...

(Total for Question 12 = 6 marks)



- 13 Many electrical devices may be charged using induction chargers. The photograph shows a watch that is charged in this way and its charger.



Induction charging does not require a metal connection between the charger and the device. The battery in the watch is charged by placing the watch on top of the charger.

The charger contains a coil. When the charger is plugged into the electrical supply, there is a current in this coil.

The watch also contains a coil in a circuit that includes the battery.

- *(a) Explain how this arrangement produces a current in the watch circuit.

(4)

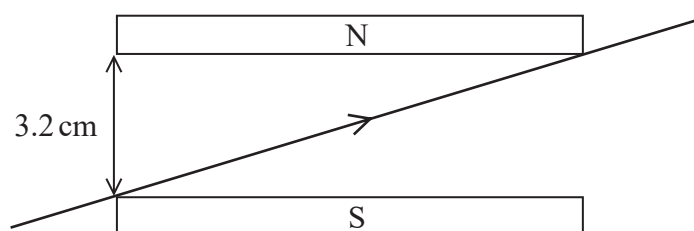
- (b) To charge the battery, the watch circuit must contain a diode between the coil and the battery. State why the diode is necessary.

(1)

(Total for Question 13 = 5 marks)



- 14 A current-carrying wire is placed between the poles of a U-shaped magnet as shown in the diagram.



- (a) Determine the magnitude of the force on the wire due to the magnetic field. You may assume the field is uniform.

current in wire = 820 mA

length of wire in field = 6.9 cm

magnetic flux density = 0.074 T

(3)

Magnitude of force = ...

- (b) Explain the direction of this force on the wire.

(2)

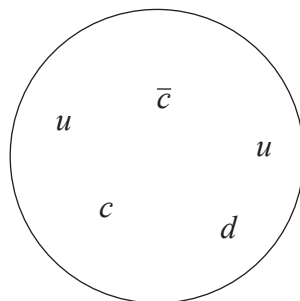
(Total for Question 14 = 5 marks)



15 In 2015, scientists at CERN announced the discovery of a particle known as a pentaquark.

At this time the pentaquark structure had not been determined. It was suggested that it might be five quarks tightly bound as a single particle, or a 'meson-baryon molecule'.

The diagram illustrates the single particle model.

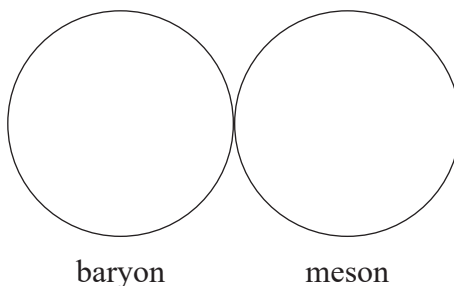


(a) The table shows the charges of the six types of quark.

Quark			Charge
u	c	t	$\frac{2}{3}e$
d	s	b	$-\frac{1}{3}e$

Complete the following diagram to show how the five quarks shown in the single particle model could be arranged in a 'meson-baryon molecule'. The meson should have charge zero and the baryon should have charge $+e$.

(3)



(b) The pentaquark has a mass of $4.38 \text{ GeV}/c^2$.

Calculate the mass of the pentaquark in kg.

(3)

.....

.....

.....

.....

Mass = ... kg



(c) The pentaquark was produced in the decay of a lambda-zero particle which was created after a collision between high energy protons.

- (i) In the experiment at CERN a lambda-zero particle was determined to have travelled 3.9 cm after its creation before decaying. The lambda-zero particle existed for 1.48×10^{-12} s.

Use these results to calculate a value of speed and comment on your answer.

(3)

- * (ii) The experiment at CERN involved colliding protons.

Explain why very high energies were required for the experiment.

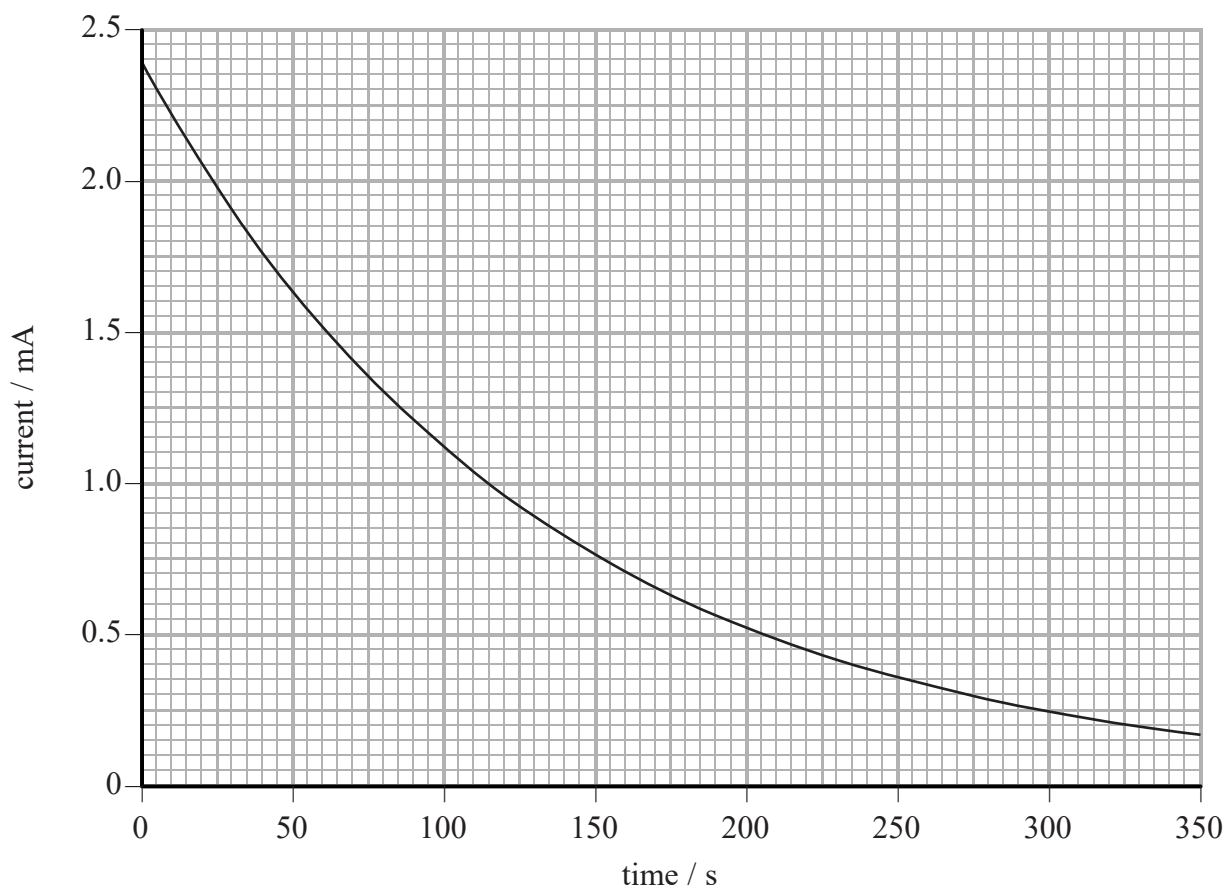
(4)

(Total for Question 15 = 13 marks)



16 A timer circuit includes a capacitor and a variable resistor in series.

- (a) The graph shows how the current in the timer circuit varies with time when the capacitor discharges through the variable resistor. The resistance of the variable resistor is $8.2\text{ k}\Omega$.



- (i) Show that the capacitance of the capacitor is about 0.02 F .

(3)



(ii) Calculate the initial charge on the capacitor.

(3)

Initial charge = ...

(iii) Calculate the energy initially stored in the capacitor.

(2)

Energy = ...

(b) In another timer circuit the capacitance of the capacitor is $470\ \mu\text{F}$. The circuit switches off when the potential difference falls to 15% of its initial value. The variable resistor is adjusted so that the timer circuit switches off after 3.5 minutes.

Calculate the resistance of the variable resistor.

(3)

Resistance = ...

(Total for Question 16 = 11 marks)



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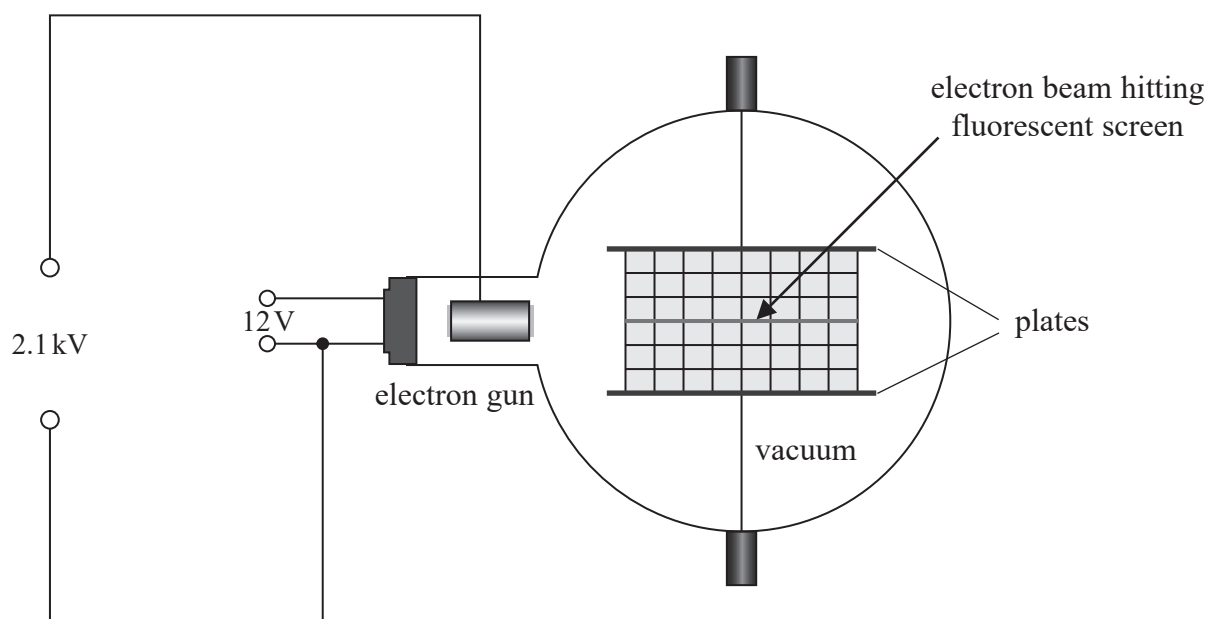
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17 The diagram shows the parts of an electron deflection tube.



- (a) The electron gun consists of a hot metal filament and a positively charged anode.

Explain how this produces a beam of electrons.

(2)

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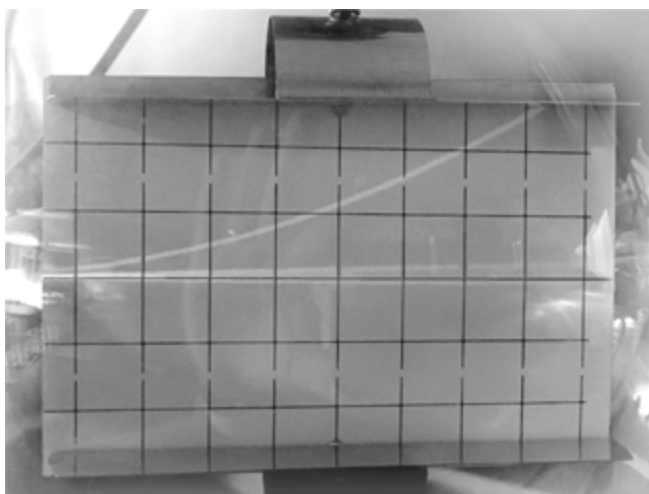
- (b) The potential difference between the hot metal filament and the anode is 2.1 kV.

Calculate the velocity of the electrons as they leave the electron gun.

(3)

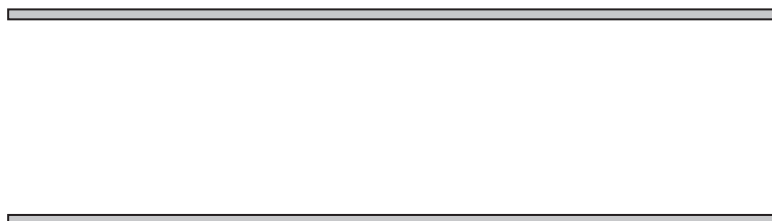
Velocity = ...

- (c) The electron beam passes between plates across which a potential difference has been applied. The electron beam is deflected, as shown in the photograph.



On the diagram below, sketch the electric field between the plates.

(2)



(d) A potential difference of 550 V is applied across the plates of another deflection tube. The vertical separation of the plates is 5.0 cm.

- (i) Show that the electrostatic force on an electron between the plates is about 2×10^{-15} N.

(3)

- (ii) The electrons in the beam enter the region between the plates with a horizontal velocity of $2.2 \times 10^7 \text{ ms}^{-1}$.

Determine the vertical deflection of the beam after travelling 10 cm horizontally between the plates.

(4)

Vertical deflection = ...

(Total for Question 17 = 14 marks)

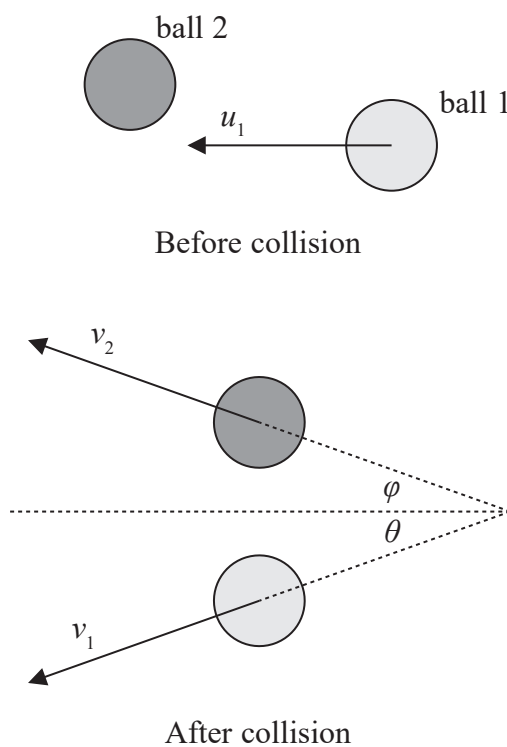


18 A student read the following extract from a textbook.

‘In an elastic collision between objects of equal mass, where one is initially stationary, the objects move off at 90° to each other after the collision.’

The student investigated this using a collision between two identical steel balls, each of mass 66 g.

(a) The diagrams illustrate the collision between the balls.



In one experiment u_1 was 0.72 m s^{-1} and θ was 29° . For such a collision it can be shown that, if the balls are to separate at 90° , then

$$v_1 = 0.63 \text{ m s}^{-1}$$

$$\phi = 61^\circ$$

$$v_2 = 0.35 \text{ m s}^{-1}$$

- (i) Show that these values satisfy the conditions for conservation of momentum in the initial direction of ball 1.

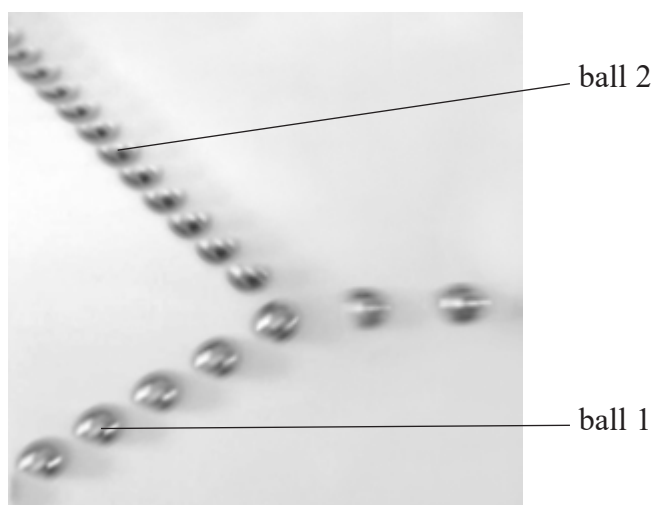
(4)

- (ii) Show that these values satisfy the condition for elastic collisions.

(3)



- (b) The photograph shows the student's actual results for this experiment. The positions of the colliding balls at successive time intervals have been overlaid on a single image.



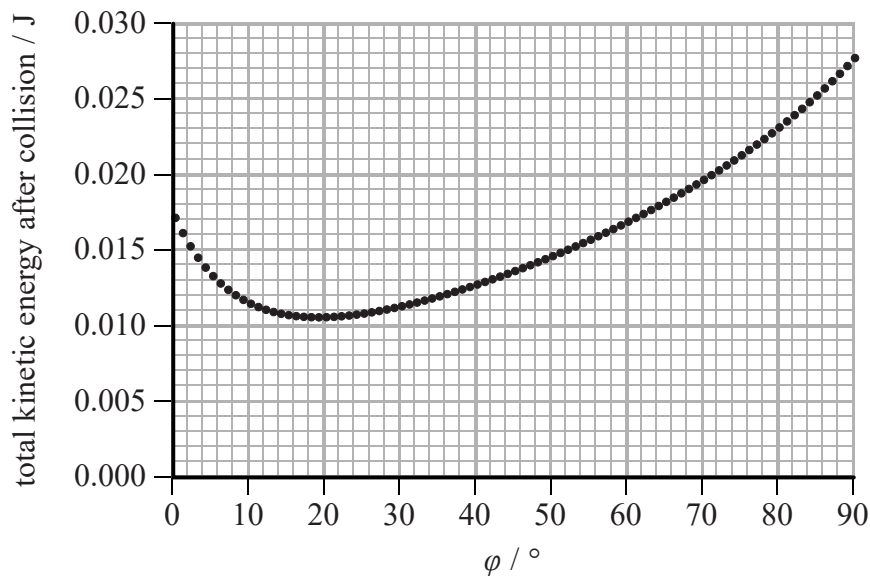
- (i) State the additional information that the student needs in order to determine the speeds of the balls.

(2)



- (ii) The student looked at the photograph and noticed that the angle between the paths of the two balls after the collision was not 90° . He modelled the collision on a computer.

He used the same initial conditions for ball 1 and the same value of θ . The computer calculated the total kinetic energy after the collision for a range of angles ϕ . The following graph was produced.



Measure ϕ from the photograph and use the graph to suggest why the angle between the paths is not 90° .

(3)

(Total for Question 18 = 12 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS



List of data, formulae and relationships

Acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$	
Coulomb's law constant	$k = 1/4\pi\epsilon_0$ $= 8.99 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$	
Electron charge	$e = -1.60 \times 10^{-19} \text{ C}$	
Electron mass	$m_e = 9.11 \times 10^{-31} \text{ kg}$	
Electronvolt	$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$	
Gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	
Gravitational field strength	$g = 9.81 \text{ N kg}^{-1}$	(close to Earth's surface)
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$	
Proton mass	$m_p = 1.67 \times 10^{-27} \text{ kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^8 \text{ m s}^{-1}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27} \text{ kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{\text{grav}} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\epsilon$ where Stress $\sigma = F/A$ Strain $\epsilon = \Delta x/x$
Elastic strain energy	$E_{\text{el}} = \frac{1}{2}F\Delta x$



Unit 2*Waves*

Wave speed

$$v = f\lambda$$

Refractive index

$${}_1\mu_2 = \sin i / \sin r = v_1 / v_2$$

Electricity

Potential difference

$$V = W/Q$$

Resistance

$$R = V/I$$

Electrical power, energy and efficiency

$$P = VI$$

$$P = I^2R$$

$$P = V^2/R$$

$$W = VIt$$

$$\% \text{ efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\% \text{ efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

Resistivity

$$R = \rho l/A$$

Current

$$I = \Delta Q / \Delta t$$

$$I = nqvA$$

Resistors in series

$$R = R_1 + R_2 + R_3$$

Resistors in parallel

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Quantum physics

Photon model

$$E = hf$$

Einstein's photoelectric equation

$$hf = \phi + \frac{1}{2}mv_{\max}^2$$



Unit 4**Mechanics**

Momentum

$$p = mv$$

Kinetic energy of a
non-relativistic particle

$$E_k = p^2/2m$$

Motion in a circle

$$v = \omega r$$

$$T = 2\pi/\omega$$

$$F = ma = mv^2/r$$

$$a = v^2/r$$

$$a = r\omega^2$$

Fields

Coulomb's law

$$F = kQ_1Q_2/r^2 \text{ where } k = 1/4\pi\epsilon_0$$

Electric field

$$E = F/Q$$

$$E = kQ/r^2$$

$$E = V/d$$

Capacitance

$$C = Q/V$$

Energy stored in capacitor

$$W = \frac{1}{2}QV$$

Capacitor discharge

$$Q = Q_0 e^{-t/RC}$$

In a magnetic field

$$F = BIl \sin \theta$$

$$F = Bqv \sin \theta$$

$$r = p/BQ$$

Faraday's and Lenz's laws

$$\epsilon = -d(N\phi)/dt$$

Particle physics

Mass-energy

$$\Delta E = c^2 \Delta m$$

de Broglie wavelength

$$\lambda = h/p$$

