Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | Candidate Number

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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P 4 8 3 6 3 A 0 1 2 4

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** $N\ A^{-1}\ m^{-1}$

☒ **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)

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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** $\dfrac{14 \times \pi}{6}$

☒ **B** $\dfrac{14 \times 2\pi}{6}$

☒ **C** $\dfrac{6 \times \pi}{14}$

☒ **D** $\dfrac{6 \times 2\pi}{14}$

(Total for Question 4 = 1 mark)

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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)

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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)

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7 ${}^{14}_{6}C$ 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 ${}^{14}_{6}C$?

	Number of neutrons	Number of protons
☒ **A**	6	8
☒ **B**	14	8
☒ **C**	8	6
☒ **D**	14	6

(Total for Question 7 = 1 mark)

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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)

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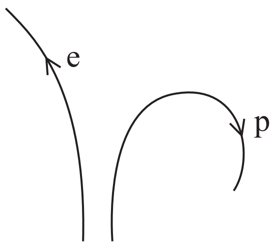
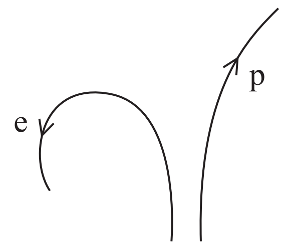
10 A proton p and an electron e, with the same velocity, enter a magnetic field which is perpendicular to the direction of their motion. The field acts into the page.

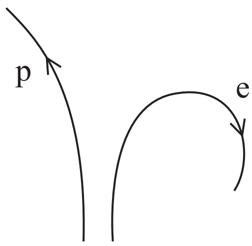
Which of the following diagrams best represents the motion of the particles?



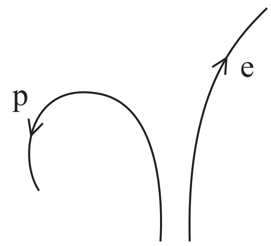
☒ **A**



☒ **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)

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 $E_k = p^2/2m$

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

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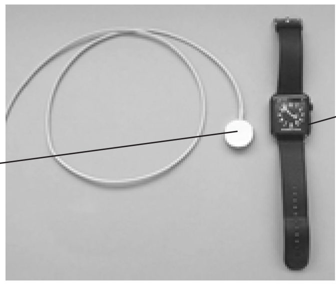
de Broglie wavelength = ...

(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.

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(b) To charge the battery, the watch circuit must contain a diode between the coil and the battery.

State why the diode is necessary.

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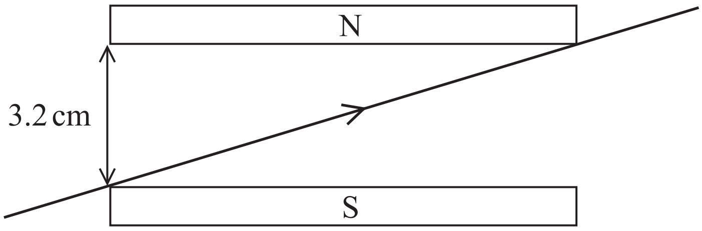
(Total for Question 13 = 5 marks)

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)

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Magnitude of force = ...

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

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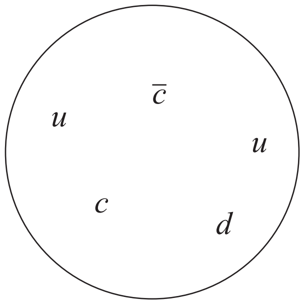
(Total for Question 14 = 5 marks)

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.

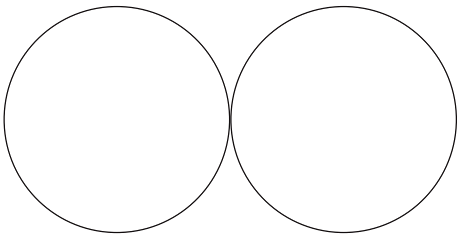


(a) The table shows the charges of the six types of quark.

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)



baryon meson

(b) The pentaquark has a mass of 4.38 GeV/c^2.

Calculate the mass of the pentaquark in kg.

(3)

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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.

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

Explain why very high energies were required for the experiment.

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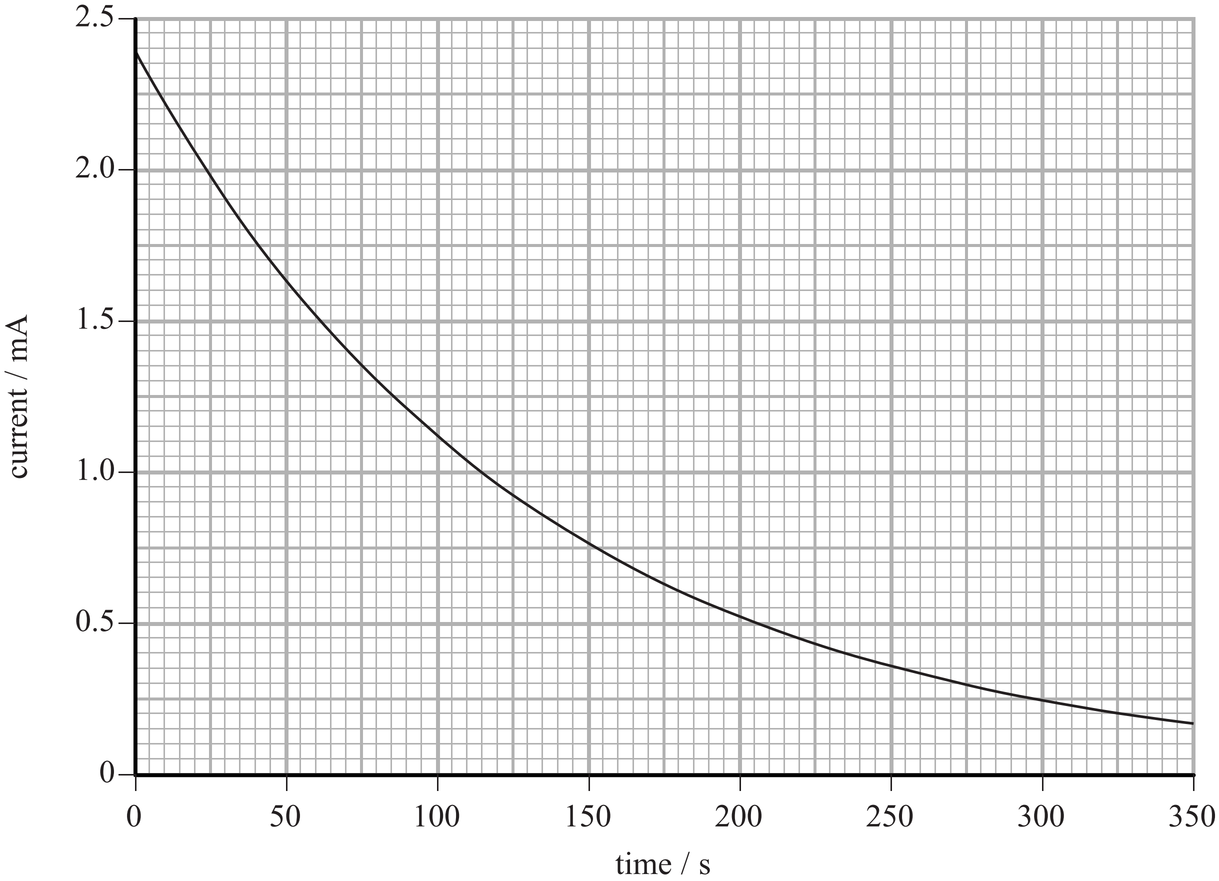
(Total for Question 15 = 13 marks)

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 $8.2\,k\Omega$.



(i) Show that the capacitance of the capacitor is about $0.02\,F$.

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(ii) Calculate the initial charge on the capacitor.

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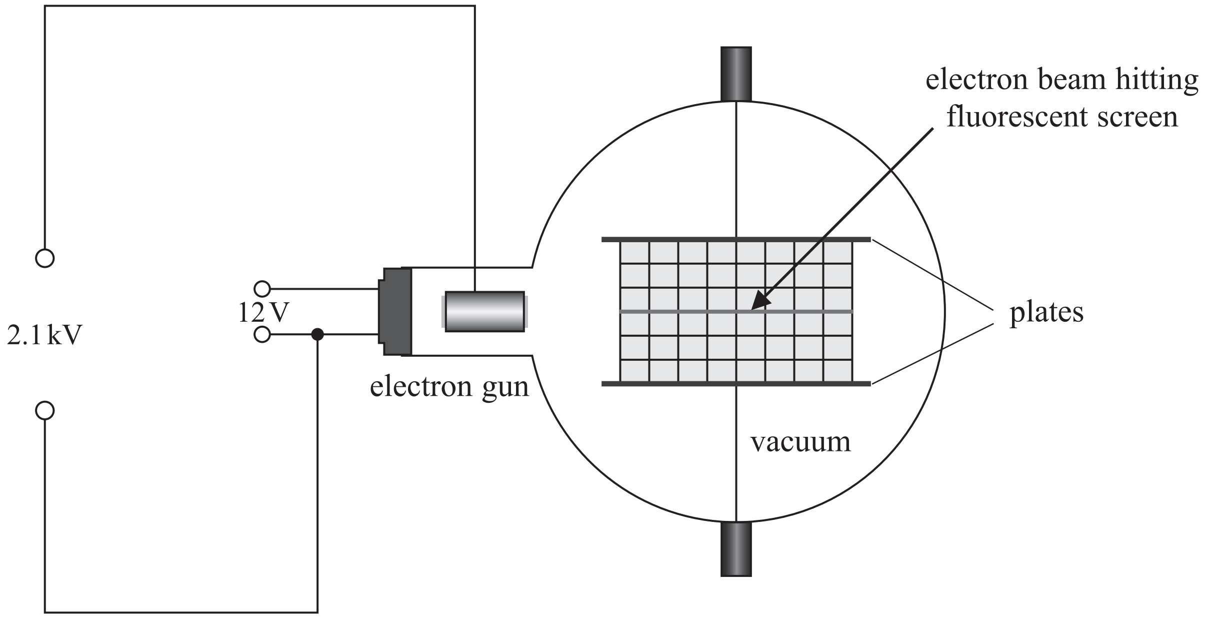
17 The diagram shows the parts of an electron deflection tube.



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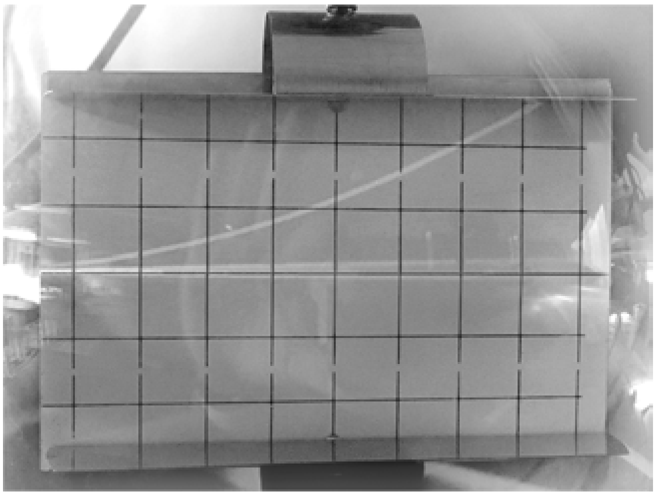
(b) The potential difference between the hot metal filament and the anode is 2.1 kV.

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

(3)

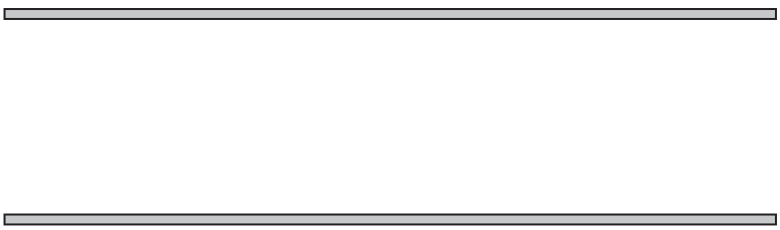
Velocity = ...

(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)



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(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.

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

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

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Vertical deflection = ...

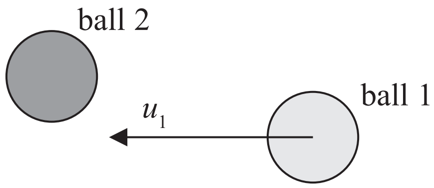
(Total for Question 17 = 14 marks)

18 A student read the following extract from a textbook.

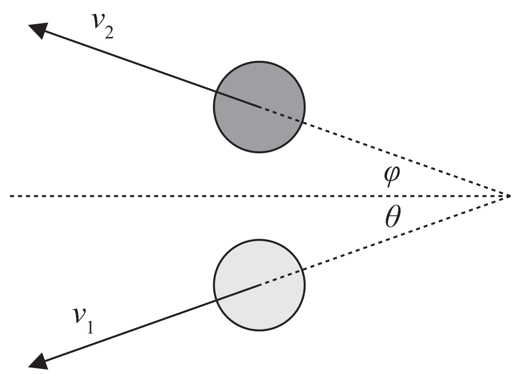
'In an elastic collision between objects of equal mass, where one is initially stationary, the objects move off at 90° to each other after the collision.'

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.



Before collision



After collision

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

$v_1 = 0.63\,\mathrm{m\,s^{-1}}$
$\varphi = 61°$
$v_2 = 0.35\,\mathrm{m\,s^{-1}}$

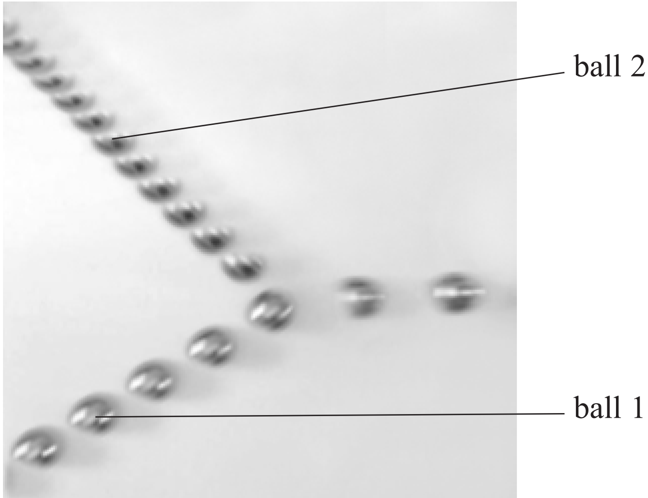
(i) Show that these values satisfy the conditions for conservation of momentum in the initial direction of ball 1.

(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.

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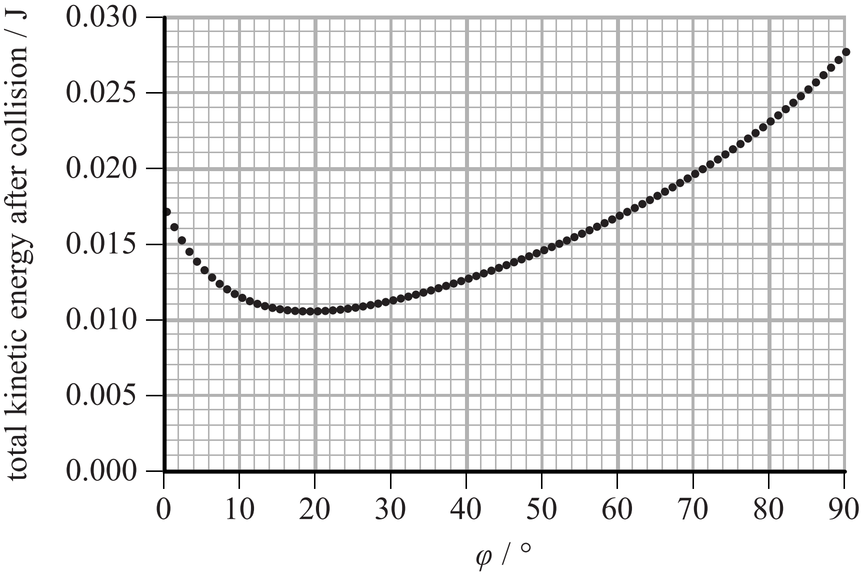
(ii) The student looked at the photograph and noticed that the angle between the paths of the two balls after the collision was not 90°. He modelled the collision on a computer.
He used the same initial conditions for ball 1 and the same value of θ. The computer calculated the total kinetic energy after 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°.

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(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	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9} \text{ N m}^2 \text{ C}^{-2}$	
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	$\varepsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$	
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	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

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	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

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

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	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
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	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

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