Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Physics

Advanced
Unit 4: Physics on the Move

Thursday 11 June 2015 – Morning
Time: 1 hour 35 minutes

Paper Reference
6PH04/01

You do not need any other materials.

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.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 4 9 2 6 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 The number of neutrons in a nucleus of $^{238}_{92}U$ is

☒ **A** 92

☒ **B** 146

☒ **C** 238

☒ **D** 330

(Total for Question 1 = 1 mark)

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2 A particle of mass *m*, has a velocity *v* and momentum *p*.

Which of the following is correct for this particle?

☒ **A** $mv^2/2 = p^2$

☒ **B** $m^2v^2/2 = p^2$

☒ **C** $m^2v^2 = p^2/m$

☒ **D** $mv^2 = p^2/m$

(Total for Question 2 = 1 mark)

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3 Which of the following is **not** a valid conclusion from Rutherford's alpha scattering experiment?

☒ **A** The nucleus is charged.

☒ **B** The nucleus contains neutrons and protons.

☒ **C** The nucleus contains most of the mass of the atom.

☒ **D** The nucleus must be very small compared to the atom.

(Total for Question 3 = 1 mark)

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4 Electrons are released from a heated metal filament.

This process is known as

☒ **A** excitation.

☒ **B** ionisation.

☒ **C** photoelectric emission.

☒ **D** thermionic emission.

(Total for Question 4 = 1 mark)

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5 Which of the following is a possible unit for rate of change of momentum?

☒ **A** kg m s^{-2}

☒ **B** kg m s^{-1}

☒ **C** N s^{-1}

☒ **D** N s

(Total for Question 5 = 1 mark)

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6 A length of current-carrying wire is placed at right angles to a uniform magnetic field of flux density B. When the current in the wire is I the force acting on the wire is F.

What is the force when the flux density is increased to $2B$ and the current reduced to $0.25I$?

☒ **A** $8F$

☒ **B** $2F$

☒ **C** $F/2$

☒ **D** $F/4$

(Total for Question 6 = 1 mark)

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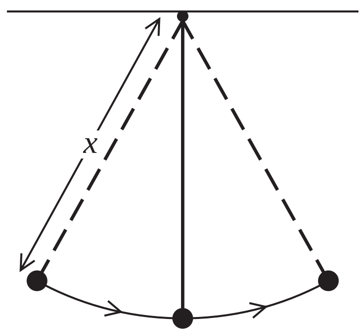
7 A pendulum consists of a bob of mass m and a string of length x.

The diagram shows the pendulum swinging through the arc of a circle. At the bottom of its swing the tension in the string is T and the velocity of the bob is v.



Which of the following is correct for the bob at the bottom of the swing?

☒ **A** $T = \frac{mv^2}{x} - mg$

☒ **B** $T = \frac{mv^2}{x} + mg$

☒ **C** $T = mg - \frac{mv^2}{x}$

☒ **D** $T = \frac{mv^2}{x}$

(Total for Question 7 = 1 mark)

8 What is the acceleration of an electron at a point in an electric field where the electric field strength is 2.0×10^4 N C^{-1}?

☒ **A** 2.8×10^{-16} m s^{-2}

☒ **B** 3.2×10^{-15} m s^{-2}

☒ **C** 1.8×10^{11} m s^{-2}

☒ **D** 3.5×10^{15} m s^{-2}

(Total for Question 8 = 1 mark)

9 The equation $\Delta E = c^2\Delta m$ can be used with data at the back of this paper to calculate

☒ **A** the kinetic energy of an electron.

☒ **B** the energy produced when a lambda particle decays.

☒ **C** the energy of the photons produced when a proton and an antiproton annihilate.

☒ **D** the mass of uranium that produces 50 MJ of energy in a nuclear reactor.

(Total for Question 9 = 1 mark)

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

Very high energies are required to

☒ **A** annihilate protons and antiprotons.

☒ **B** allow protons to collide with other protons.

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

☒ **D** to produce individual quarks.

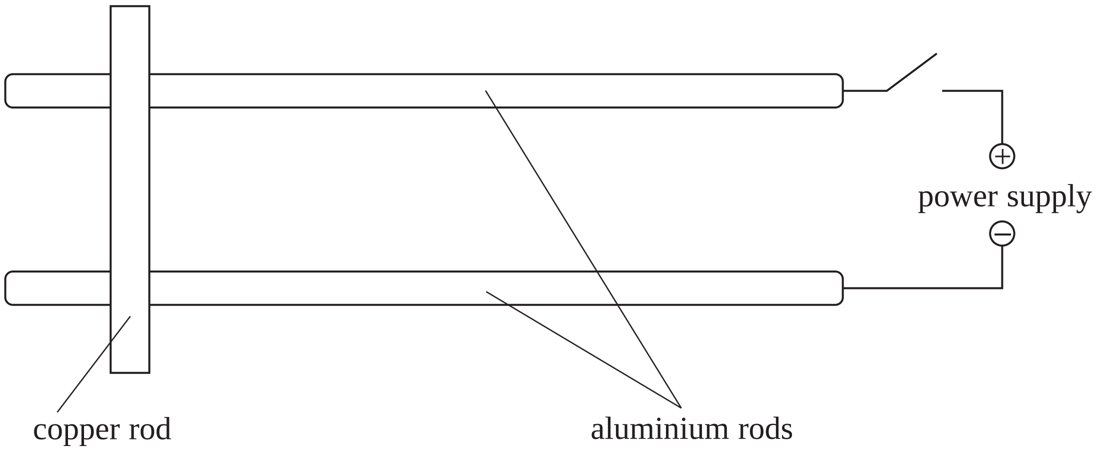
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The apparatus shown in the diagram can be used to demonstrate that a force acts on a current-carrying conductor when the conductor is in a magnetic field.



The apparatus is placed in a magnetic field. When the switch is closed, the copper rod rolls along the aluminium rods.

(a) Add to the diagram to indicate the direction of the current in the copper rod.

(1)

(b) State the direction of the magnetic field that will make the copper rod move to the right.

(2)

(Total for Question 11 = 3 marks)

12 Pions belong to a group of particles called mesons. Pions can be used in a form of radiotherapy to treat brain tumours.

(a) The table lists some quarks and their charges.

Quark	**Charge/*e***
u	+2/3
d	–1/3
s	–1/3

From the list below circle the quark combination which could correspond to a π^- pion.

(1)

dds $\quad \bar{u}d \quad \bar{u}\bar{u}\bar{d} \quad \bar{s}u$

(b) The mass of a pion is 140 MeV/c^2.

Calculate the mass of a pion in kg.

(3)

Mass =

(Total for Question 12 = 4 marks)

13 The photograph is of a roundabout in a children's playground.

A child of mass 20 kg sits on the roundabout without holding the bars.

The distance from the centre of the roundabout to the centre of gravity of the child is 0.80 m. The maximum frictional force between the roundabout and the child is 0.35 × the weight of the child.

(a) Calculate the minimum time taken for one revolution of the roundabout if the child is not to slide off.

(4)

Minimum time =

(b) State and explain how this time would change if a child of larger mass sat at the same place on the roundabout.

(2)

(Total for Question 13 = 6 marks)

***14** The photograph shows a probe moving in space.

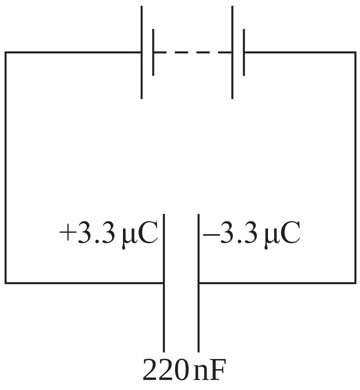
Whilst moving, empty fuel tanks can be ejected by means of an explosion. This has the effect of increasing the speed of the probe.

Discuss whether conservation of momentum and conservation of energy apply in this situation and why the speed of the probe increases.

(6)

(Total for Question 14 = 6 marks)

15 A capacitor is charged by a battery as shown in the circuit diagram.



(a) Calculate the e.m.f. of the battery and the energy stored in the charged capacitor.

(4)

E.m.f. =

Energy =

(b) The capacitor is disconnected from the battery and discharged through a 20 MΩ resistor.

Calculate the time taken for 80% of the charge on the capacitor to discharge through the resistor.

(3)

Time taken =

(c) Use an equation to explain whether the time taken for the capacitor to lose half its energy is greater or less than the time taken to lose half its charge.

(3)

(d) A student carries out an experiment to record data so that she can plot a graph of potential difference against time as the capacitor discharges.

State **two** advantages of using a datalogger rather than a voltmeter and stopwatch to record this data.

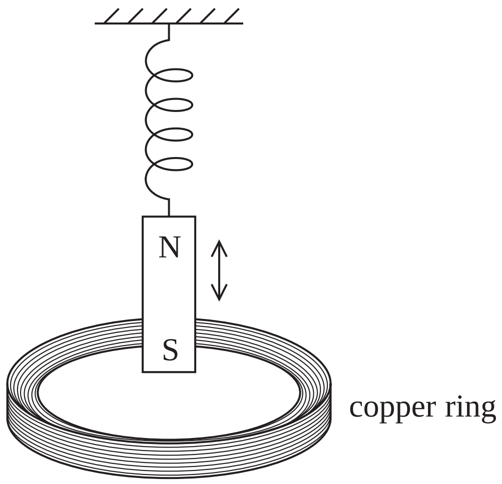
(2)

(Total for Question 15 = 12 marks)

16 (a) State Faraday's law of electromagnetic induction.

(2)

*(b) A magnet is attached to the end of a spring as shown in the diagram.



The magnet is displaced vertically and released so that it oscillates.
Explain why this produces an alternating current in the copper ring.

(4)

(c) The average vertical component of the magnetic flux density through the coil varies at a maximum rate of 0.035 T s^{-1}.
Calculate the maximum current in the copper ring.

radius of copper ring = 5.0 cm
resistance of copper ring = 6.7×10^{-5} Ω

(4)

Maximum current =

(Total for Question 16 = 10 marks)

17 (a) Coulomb's law for the force F between point charges Q_1 and Q_2, which are a distance r apart, is given by

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$$

Express the unit of ε_0 in base units.

(3)

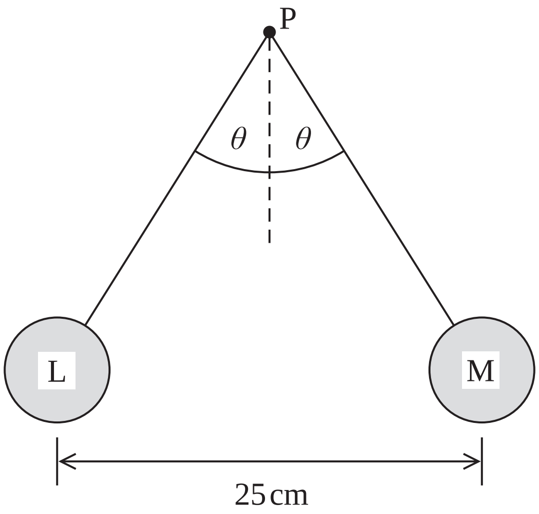
(b) Electric fields are caused by both point charges and by parallel plates with a potential difference across them.

Describe the difference between the electric field caused by a point charge and the electric field between parallel plates. Your answer should include a diagram of each type of field and reference to electric field strength.

(5)

(c) Two small spheres L and M are attached to non-conducting threads and suspended from a point P. Each sphere is given an equal positive charge of 4.0×10^{-7} C. The spheres hang in equilibrium as shown in the diagram.

The mass of each sphere is 2.7 g.



By considering the forces acting on one of the spheres, calculate the tension in the thread and the angle θ.

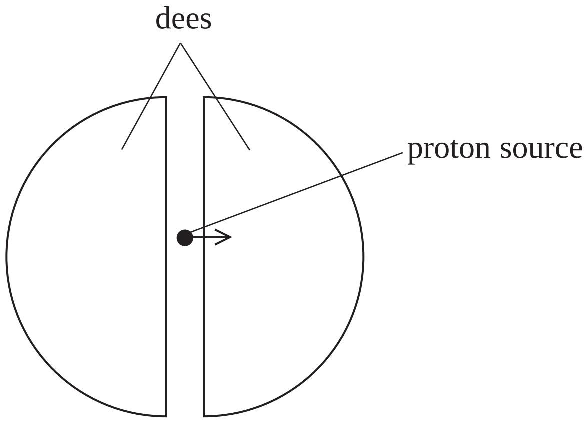
(6)

Tension =

θ =

(Total for Question 17 = 14 marks)

18 (a) A cyclotron is a particle accelerator which can be used to accelerate protons. The cyclotron consists of two semicircular electrodes called 'dees'. An alternating potential difference is applied across the gap between the dees. A uniform magnetic field is applied at right angles to the plane of the dees.



(i) Complete the diagram to show the path of the protons.

(1)

(ii) State the direction of the magnetic field needed in order to produce the path you have sketched.

(1)

(iii) Explain how the kinetic energy of the protons is increased as they follow the path you have shown.

(3)

(iv) Show that the magnetic flux density B of the applied magnetic field is given by

$$B = \frac{2\pi f m}{e}$$

where f is the frequency of the alternating potential difference, m is the mass of the proton and e is the charge on the proton.

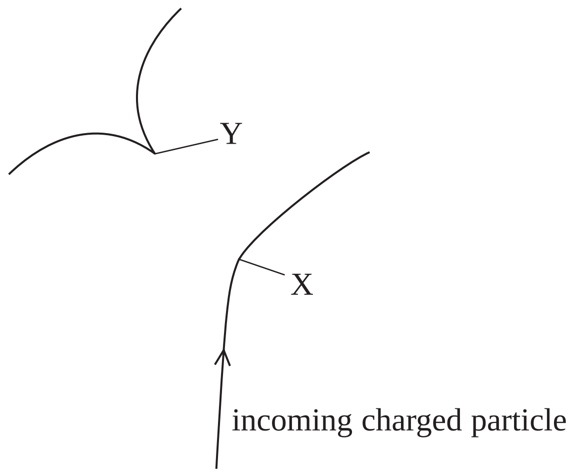
(3)

(v) In a particular cyclotron B is 1.2 mT.
Calculate the frequency f of the alternating potential difference.

(2)

f =

(b) The diagram shows the tracks produced in a bubble chamber.



At X an incoming charged particle interacts with a stationary proton.

Describe and explain what can be deduced about the interaction at X and subsequent events. You may add to the diagram to help your answer.

(5)

(Total for Question 18 = 15 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	$E_{el} = \frac{1}{2}F\Delta x$

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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$
	$\% \text{ efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$
	$\% \text{ efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
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	$\dfrac{1}{R} \quad \dfrac{1}{R_1} \quad \dfrac{1}{R_2} \quad \dfrac{1}{R_3}$

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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