Pearson Edexcel International Advanced Level

**Monday 12 January 2026**

Morning (Time: 1 hour 45 minutes)

| Paper reference | WPH14/01A |
|---|---|

# Physics

## International Advanced Level
## UNIT 4: Further Mechanics, Fields and Particles
## Question Paper

**You must have:**
Scientific calculator and Answer book (sent separately).
Do not return this question paper with the answer book.

### Information

- The list of data, formulae and relationships is printed at the end of this booklet.

*Turn over*

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P 8 7 6 4 3 A

Pearson

## SECTION A

**Answer ALL questions.**

**1** A neutron can decay to produce a proton.

Which of the following equations correctly shows neutron decay?

**A** $n \rightarrow p + e^{+} + \overline{v}_{e}$

**B** $n \rightarrow p + e^{+} + v_{e}$

**C** $n \rightarrow p + e^{-} + \overline{v}_{e}$

**D** $n \rightarrow p + e^{-} + v_{e}$

**(Total for Question 1 = 1 mark)**

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**2** A ball of mass $m$ travelling with velocity $v$ strikes a wall at right angles. It bounces off the wall in the opposite direction at the same speed.

Which of the following is the impulse on the wall?

**A** $mv$

**B** $2mv$

**C** $-mv$

**D** $-2mv$

**(Total for Question 2 = 1 mark)**

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**3** In an electron deflection tube, electrons are released by passing a current through a metal filament.

What is the name of the process that releases the electrons?

**A** electron diffraction

**B** ionisation

**C** photoelectric effect

**D** thermionic emission

**(Total for Question 3 = 1 mark)**

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**4** A potential difference of 0.2 V is applied across parallel plates with a separation of 4 cm.

What is the electric field strength halfway between the plates, in units of $V\,m^{-1}$?

**A** 0.05

**B** 0.1

**C** 5

**D** 10

**(Total for Question 4 = 1 mark)**

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**5** A particle of mass *m* has momentum *p* and kinetic energy $E_k$. A second particle of mass *m*/2 has momentum 2*p*.

What is the kinetic energy of the second particle?

**A** $E_k/8$

**B** $E_k/2$

**C** $2E_k$

**D** $8E_k$

**(Total for Question 5 = 1 mark)**

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**6** A particle has a mass of $3.17 \times 10^{-27}$ kg.

Which of the following gives the mass in $GeV/c^2$?

**A** $\dfrac{3.17 \times 10^{-27} \times 10^{9} \times 1.6 \times 10^{-19}}{3.00 \times 10^{8}}$

**B** $\dfrac{3.17 \times 10^{-27} \times 10^{9} \times 1.6 \times 10^{-19}}{\left(3.00 \times 10^{8}\right)^{2}}$

**C** $\dfrac{3.17 \times 10^{-27} \times \left(3.00 \times 10^{8}\right)^{2}}{1.6 \times 10^{-19}}$

**D** $\dfrac{3.17 \times 10^{-27} \times \left(3.00 \times 10^{8}\right)^{2}}{10^{9} \times 1.6 \times 10^{-19}}$

**(Total for Question 6 = 1 mark)**

**7** A charged capacitor is connected across a resistor of resistance $R$ and the current in the resistor is measured.

A graph of ln (current) against time is plotted and the gradient of the graph is determined.

Which of the following gives the capacitance of the capacitor?

**A** $-\text{gradient} \times \text{R}$

**B** $-\dfrac{1}{\text{gradient} \times R}$

**C** $-\dfrac{R}{\text{gradient}}$

**D** $-\dfrac{\text{gradient}}{R}$

**(Total for Question 7 = 1 mark)**

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**8** A particle accelerator produces a beam of very high energy protons.

Which of the following statements describes the speed of a proton as it passes through the accelerator?

**A** It increases uniformly.

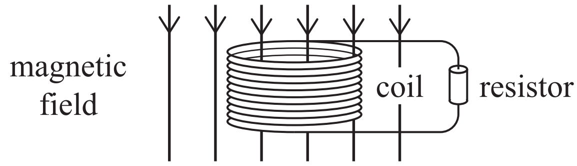
**B** It never reaches the speed of light.

**C** It stops increasing when it reaches the speed of light.

**D** It reduces as it approaches the speed of light.

**(Total for Question 8 = 1 mark)**

**9** A coil of wire is connected to a resistor, as shown.




The magnetic flux density of the field through the coil is increased steadily from zero to a maximum value.

Which of the following single changes would result in a smaller current in the resistor?

**A** increasing the area of the coil in the magnetic field

**B** increasing the maximum flux density

**C** increasing the number of turns on the coil

**D** increasing the time taken to reach the maximum flux density

**(Total for Question 9 = 1 mark)**

---

**10** The structure of nucleons can be investigated using electrons with high energies.

Which of the following is the reason why high energies are required?

**A** to allow for the creation of new particles

**B** to overcome the repulsive electrostatic forces

**C** to produce a relativistic increase in particle lifetime

**D** to produce short de Broglie wavelengths

**(Total for Question 10 = 1 mark)**

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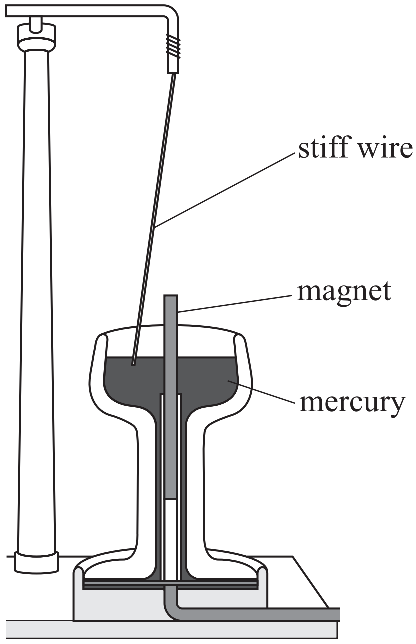
**TOTAL FOR SECTION A = 10 MARKS**

## SECTION B

**11** In 1821, Michael Faraday made what is believed to be the first electric motor, as shown below.




The stiff wire was suspended freely from a stand. The mercury completed an electrical circuit, which included the wire. When there was a current in the wire, the wire moved around the magnet.

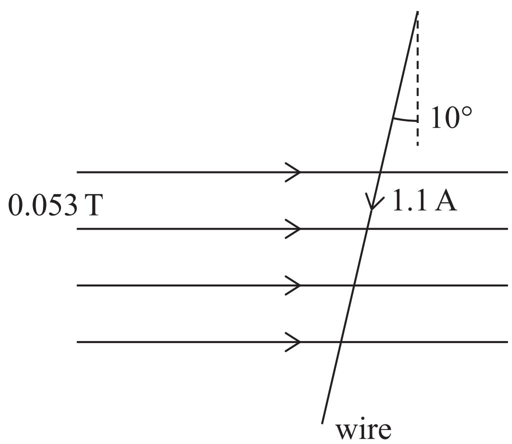
(a) The wire made 10 complete revolutions around the magnet in a time of 8.3 s.

Calculate the angular velocity of the wire.

**(3)**

(b) When the current in the wire is 1.1 A, the wire is at an angle of 10º to the vertical.

The length of the wire in the horizontal magnetic field is 3.5 cm.




Determine the force on the wire.

magnetic flux density = 0.053 T

**(3)**

**(Total for Question 11 = 6 marks)**

**12** DART is a spacecraft sent to collide with an asteroid on course for Earth.

After colliding with one another, DART and the asteroid will stick together.

DART will have a speed of $6250\,\text{m}\,\text{s}^{-1}$ when it collides with the asteroid. This causes a change in the asteroid's speed of $0.40\,\text{mm}\,\text{s}^{-1}$.

(a) Determine the combined mass of DART and the asteroid.

mass of DART = 300 kg

**(3)**

(b) DART collides at 90° to the direction of the asteroid's velocity.

The asteroid is moving at a speed of $0.16\,\text{m}\,\text{s}^{-1}$.

Calculate the angle through which the velocity of the asteroid is deflected.

**(2)**

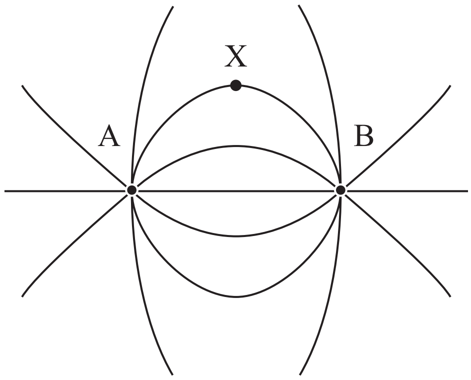
**(Total for Question 12 = 5 marks)**

**13** (a) Two point charges of $3.1 \times 10^{-9}$ C and $-2.4 \times 10^{-8}$ C are placed a distance of 0.043 m apart in a vacuum.

Calculate the magnitude of the force between the charges.

**(2)**

(b) The diagram represents the electric field around two point charges of equal magnitude. A is a positive charge and B is a negative charge.




(i) State the meaning of electric field strength.

**(1)**

(ii) Deduce the direction of the electric field at X.

You should consider the electric field at X due to A and due to B separately.

**(4)**

**(Total for Question 13 = 7 marks)**

**14** A lambda ($\Lambda$) particle is a baryon.

(a) State the structure of a baryon.

**(1)**

(b) A neutral $\Lambda$ particle can decay into a proton and a pion.

(i) Write this decay as a particle equation.

**(1)**

$\Lambda_0 \rightarrow$

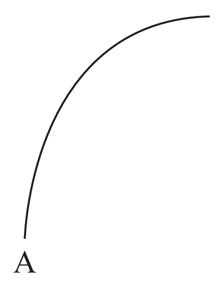
(ii) Explain how the laws of conservation of momentum and mass-energy apply to this decay process.

Assume the $\Lambda$ particle is stationary.

**(4)**

(c) Scientists studying antimatter recently observed the creation of an antihelium nucleus, which consists of two antiprotons and two antineutrons.

The diagram represents the path of a proton through a magnetic field starting at point A.




An antihelium nucleus also starts at point A and initially travels with the same velocity as the proton.

Explain the path of the antihelium nucleus.

You should add to the diagram the path of the antihelium nucleus.

**(4)**

**(Total for Question 14 = 10 marks)**

**15** Muons are produced in the Earth's upper atmosphere at a speed of 0.994 $c$.

The number of muons reaching the Earth's surface and the number reaching a position 1600 m higher up was measured. 74% of the muons detected at 1600 m reached the Earth's surface without decaying.

Explain whether these observations are consistent with relativistic effects.

Your answer should include a calculation.

average lifetime of muons at rest = $2.2 \times 10^{-6}$ s

**(Total for Question 15 = 5 marks)**

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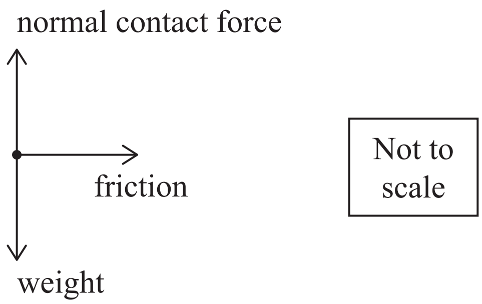
**16** A go-kart is a small racing car. A go-kart track is being designed.

The track has semicircular ends with straight track in between, as shown.


The track must allow the go-kart to travel around the bends at a maximum safe speed of 35.0 km per hour (9.72 m $s^{-1}$).

(a) The first design has a horizontal track.

As the go-kart goes round the semicircular end of the track, centripetal force is provided by friction between the track and the tyres. This is shown in the free body force diagram below.



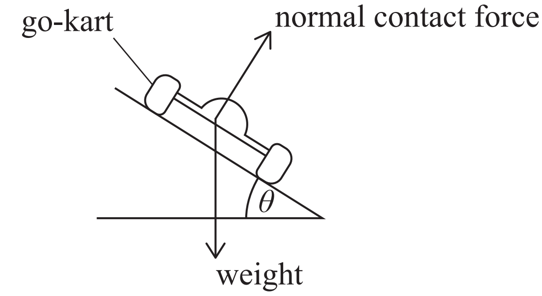

Determine whether the go-kart travels around the semicircular ends without exceeding the maximum frictional force.

maximum frictional force = 1180 N

mass of go-kart and driver = 185 kg

**(2)**

(b) A second design uses a track that is banked at the semicircular ends. The track is banked at an angle $\theta$ to the horizontal.




At a speed $v$, the go-kart follows the track without any frictional force perpendicular to its motion.

(i) Show that

$$\tan\theta = \frac{2v^2}{gd}$$

where $d$ is the diameter of the semicircular end.

**(3)**

(ii) Calculate the angle $\theta$ for a go-kart travelling at the maximum safe speed.

**(2)**

(c) A banked track will cost more to build.

Suggest whether there are any significant advantages that would justify the cost.

**(2)**

**(Total for Question 16 = 9 marks)**

**17** Experiments, supervised by Rutherford one hundred years ago, involved firing alpha particles at thin gold foil.

(a) The observations from these experiments are summarised in the table.

Complete the table with the corresponding conclusions from these observations.

**(3)**

| Observation | Conclusion |
|---|---|
| The vast majority of alpha particles go straight through without any deflection. | |
| A tiny proportion of the alpha particles is deflected through angles greater than 90°. | |

(b) A gold nucleus has the symbol ${}^{197}_{79}\mathrm{Au}$.

(i) Determine the number of neutrons in a gold nucleus

**(1)**

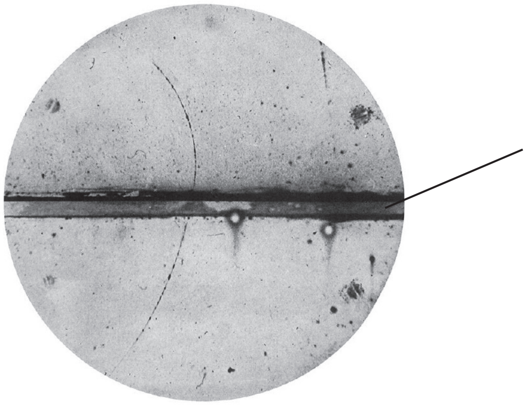
(ii) At one moment during the experiment, an alpha particle was at a distance of $5.0 \times 10^{-14}$ m from the gold nucleus.

Calculate the electric potential due to the gold nucleus at this distance.

**(3)**

**(Total for Question 17 = 7 marks)**

**18** In 1932, Carl Anderson published this photograph of a track in a cloud chamber, as shown below. The cloud chamber contained a lead plate. There was a magnetic field perpendicular to the plane of the track.




(Source: © Anderson, Carl D. (1933). 'The Positive Electron'. *Physical Review* 43 (6): 491–494. DOI: 10.113/POhysREv.43.491)

The photograph shows the track of a positron from cosmic rays and is the first photographic record of an antiparticle.

(a) State the properties of a positron that show it is the antiparticle to the electron.

**(3)**

(b) The cloud chamber contained a lead plate. There was a magnetic field perpendicular to the plane of the track.

Deduce the direction of the magnetic field.

**(3)**

(c) In the upper part of the photograph the positron had an energy of 23 MeV.

(i) Show that the positron must have been travelling at a relativistic speed. Assume that all of its energy is kinetic energy.

**(3)**

(ii) For relativistic particles such as this positron, momentum obeys the relationship

$$E = pc$$

where $E$ = particle energy, $p$ = particle momentum and $c$ = speed of light.

Determine the magnetic flux density of the magnetic field.

radius of curvature of path = 3.7 cm

**(3)**

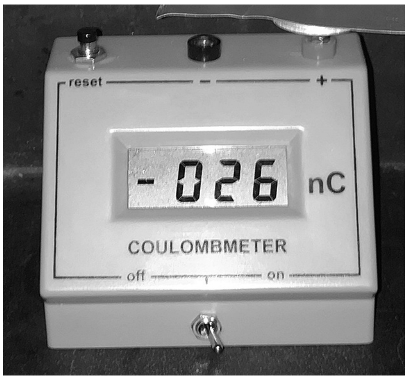
(d) A positron travelling at a non-relativistic speed of $1.5 \times 10^{7}\,\mathrm{m\,s^{-1}}$ collides with an electron travelling at the same speed in the opposite direction. The positron and electron annihilate one another resulting in the production of a photon of gamma radiation.

Deduce whether the frequency of the gamma radiation produced exceeds $1.0 \times 10^{20}\,\mathrm{Hz}$.

**(4)**

**(Total for Question 18 = 16 marks)**

**19** A digital coulombmeter measures electric charge, as shown in the photograph below.

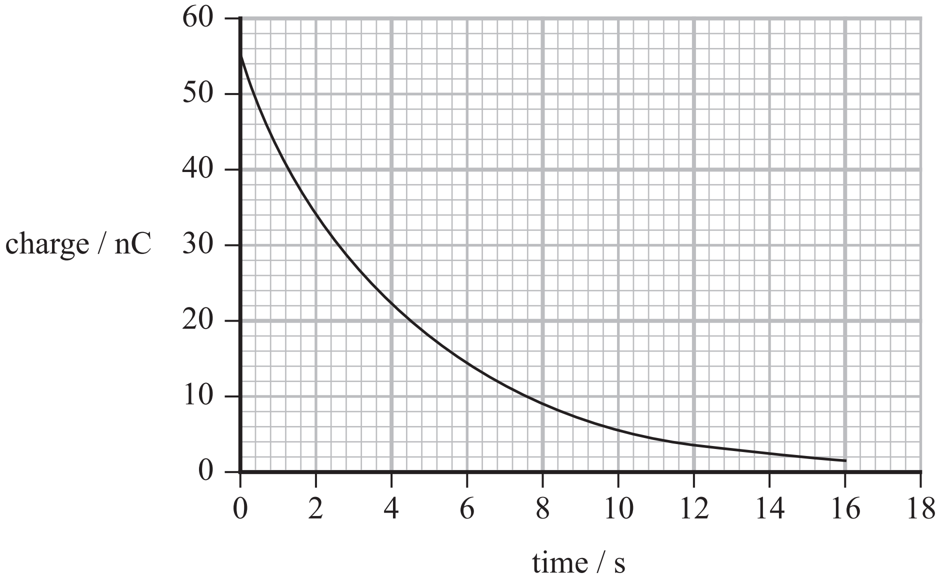



The charge the coulombmeter is measuring is stored on a capacitor. A voltmeter inside the coulombmeter measures the potential difference across the capacitor. This value is converted so that the display shows the charge in nanocoulombs.

(a) State why the voltmeter must have a very high resistance.

**(1)**

(b) A coulombmeter is charged. A resistor with resistance 4.6 MΩ is placed across the terminals and the capacitor discharges through the resistor. The charge shown on the display is recorded and a graph of charge against time is produced.




(i) Show that, using data from the graph, the capacitance of the capacitor in the coulombmeter is about $9.7 \times 10^{-7}$ F.

**(3)**

(ii) Calculate the energy initially stored by the capacitor.

**(2)**

(c) The notes with the coulombmeter state:

| |
|---|
| The coulombmeter has a much higher capacitance than the charged objects it is being used with, so effectively all of the charge is transferred to the meter. |

Explain why the charge will be transferred to the capacitor with a much higher capacitance.

**(2)**

(d) The data for the graph was obtained by using a video camera to record the coulombmeter display and replaying this frame by frame.

State an advantage of using this method.

**(1)**

**(Total for Question 19 = 9 marks)**

***20** The following passage is taken from an article about the history of particle physics.

Mystery Particle

By 1932, scientists knew of the existence of the subatomic particles: the <u>electron</u>, the <u>proton</u> and the <u>neutron</u>. These were believed to be the fundamental particles.

In 1936, scientists were using tracks of cosmic rays to identify a predicted particle known as a <u>meson</u>. Instead, another particle was discovered, the <u>muon</u>. This was so surprising that Nobel Prize winning physicist Isidor Rabi said “Who ordered that?”

Describe how the underlined particles fit into the standard model.

**(6)**

**(Total for Question 20 = 6 marks)**

**TOTAL FOR SECTION B = 80 MARKS**
**TOTAL FOR PAPER = 90 MARKS**

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## 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

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

Efficiency

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

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

*Materials*

Density $\rho = \dfrac{m}{V}$

Stokes' law $F = 6\pi\eta rv$

Hooke's law $\Delta F = k\Delta x$

Elastic strain energy $\Delta E_{\mathrm{el}} = \dfrac{1}{2}F\Delta x$

Young modulus $E = \dfrac{\sigma}{\varepsilon}$ where

Stress $\sigma = \dfrac{F}{A}$

Strain $\varepsilon = \dfrac{\Delta x}{x}$

***Unit 2***

*Waves*

| | |
|---|---|
| Wave speed | $v = f\lambda$ |
| Speed of a transverse wave on a string | $v = \sqrt{\dfrac{T}{\mu}}$ |
| Intensity of radiation | $I = \dfrac{P}{A}$ |
| Refractive index | $n_1 \sin\theta_1 = n_2 \sin\theta_2$ |
| | $n = \dfrac{c}{v}$ |
| Critical angle | $\sin C = \dfrac{1}{n}$ |
| Diffraction grating | $n\lambda = d\sin\theta$ |

*Electricity*

| | |
|---|---|
| Potential difference | $V = \dfrac{W}{Q}$ |
| Resistance | $R = \dfrac{V}{I}$ |
| Electrical power, energy | $P = VI$ |
| | $P = I^2R$ |
| | $P = \dfrac{V^2}{R}$ |
| | $W = VIt$ |
| Resistivity | $R = \dfrac{\rho l}{A}$ |
| Current | $I = \dfrac{\Delta Q}{\Delta t}$ |
| | $I = nqvA$ |
| Resistors in series | $R = R_1 + R_2 + R_3$ |
| Resistors in parallel | $\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$ |

*Particle nature of light*

| | |
|---|---|
| Photon model | $E = hf$ |
| Einstein's photoelectric equation | $hf = \phi + \frac{1}{2}mv^2_{max}$ |
| de Broglie wavelength | $\lambda = \dfrac{h}{p}$ |

***Unit 4***

*Further mechanics*

| | |
|---|---|
| Impulse | $F\Delta t = \Delta p$ |
| Kinetic energy of a non-relativistic particle | $E_k = \frac{p^2}{2m}$ |
| Motion in a circle | $v = \omega r$ |
| | $T = \frac{2\pi}{\omega}$ |
| | $a = \frac{v^2}{r}$ |
| | $a = r\omega^2$ |
| Centripetal force | $F = ma = \frac{mv^2}{r}$ |
| | $F = mr\omega^2$ |

*Electric and magnetic fields*

| | |
|---|---|
| Electric field | $E = \frac{F}{Q}$ |
| Coulomb's law | $F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$ |
| | $E = \frac{Q}{4\pi\varepsilon_0 r^2}$ |
| | $E = \frac{V}{d}$ |
| Electrical potential | $V = \frac{Q}{4\pi\varepsilon_0 r}$ |
| Capacitance | $C = \frac{Q}{V}$ |
| Energy stored in capacitor | $W = \frac{1}{2}QV$ |
| | $W = \frac{1}{2}CV^2$ |
| | $W = \frac{1}{2}\frac{Q^2}{C}$ |
| Capacitor discharge | $Q = Q_0 e^{-t/RC}$ |

Resistor-capacitor discharge $I = I_0 e^{-t/RC}$

$$V = V_0 e^{-t/RC}$$

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field $F = Bqv \sin \theta$

$$F = BIl \sin \theta$$

Faraday's and Lenz's laws $\mathscr{E} = \dfrac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

*Nuclear and particle physics*

In a magnetic field $r = \dfrac{p}{BQ}$

Mass-energy $\Delta E = c^2 \Delta m$

Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

Centre Number

Candidate Number

# Pearson Edexcel International Advanced Level

## Monday 12 January 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WPH14/01A**

# Physics

**International Advanced Level**
**UNIT 4: Further Mechanics, Fields and Particles**
**Answer Book**

**You must have:**
Scientific calculator and Question book (sent separately).

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- **Show all your working out** in calculations and **include units** where appropriate.

## 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 the question marked with an **asterisk** (*), 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.

*Turn over*

P87616A



P 8 7 6 1 6 A 0 1 2 0

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## SECTION A

**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**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

**(Total for Question 1 = 1 mark)**

**2**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

**(Total for Question 2 = 1 mark)**

**3**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

**(Total for Question 3 = 1 mark)**

**4**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

**(Total for Question 4 = 1 mark)**

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

**5**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 5 = 1 mark)**

**6**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 6 = 1 mark)**

**7**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 7 = 1 mark)**

**8**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 8 = 1 mark)**

**9**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 9 = 1 mark)**

---

**10**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 10 = 1 mark)**

---

**TOTAL FOR SECTION A = 10 MARKS**

## SECTION B

**11**

(a)

**(3)**

(b)

**(3)**

**(Total for Question 11 = 6 marks)**

**12**

(a)

**(3)**

(b)

**(2)**

**(Total for Question 12 = 5 marks)**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**13**

(a)

**(2)**

(b) (i)

**(1)**

(ii)

**(4)**

**(Total for Question 13 = 7 marks)**

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

**14**

(a)

**(1)**

(b) (i)

**(1)**

$\Lambda_0 \rightarrow$

(ii)

**(4)**

DO NOT WRITE IN THIS AREA

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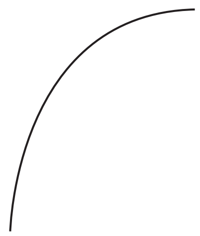
P 8 7 6 1 6 A 0 8 2 0

(c)

**(4)**



A

**(Total for Question 14 = 10 marks)**

**15**

**(5)**

**(Total for Question 15 = 5 marks)**

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**16**

(a)

**(2)**

(b) (i)

**(3)**

(ii)

**(2)**

(c)

**(2)**

**(Total for Question 16 = 9 marks)**

**17**

(a)

**(3)**

| **Conclusion** |
|---|
| |
| |

(b) (i)

**(1)**

(ii)

**(3)**

**(Total for Question 17 = 7 marks)**

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**18**

(a)

**(3)**

(b)

**(3)**

(c) (i)

**(3)**

(ii)

**(3)**

(d)

**(4)**

**(Total for Question 18 = 16 marks)**

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**19**

(a)

**(1)**

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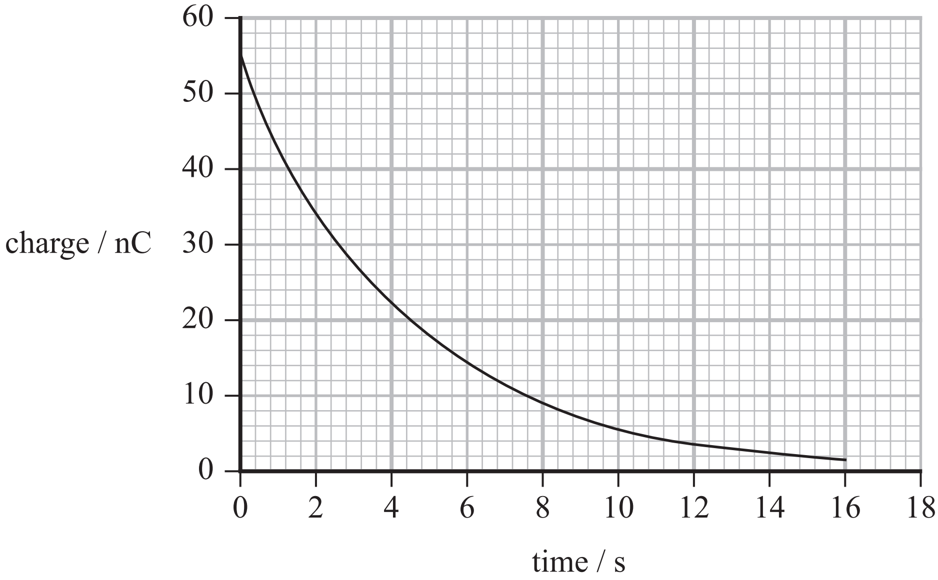
(b) (i)

**(3)**

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(ii)

**(2)**

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(c)

**(2)**

(d)

**(1)**

**(Total for Question 19 = 9 marks)**

*20

(6)

(Total for Question 20 = 6 marks)

**TOTAL FOR SECTION B = 80 MARKS**
**TOTAL FOR PAPER = 90 MARKS**

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