Paper Reference(s) 9PH0/01
Pearson Edexcel Level 3 GCE

Total Marks

Physics
Advanced
PAPER 1: Advanced Physics I

Friday 24 May 2024 – Morning

Time: 1 hour 45 minutes

In the boxes below, write your name, centre number and candidate number.

Surname						
Other names						
Centre Number						
Candidate Number						

V74468A

Pearson

YOU MUST HAVE

Scientific calculator and ruler
Data, Formulae and Relationships Booklet (enclosed)

YOU WILL BE GIVEN

Diagram Booklet

INSTRUCTIONS

Answer ALL questions.

Answer the questions in the spaces provided in this Question Paper or in the separate Diagram Booklet – there may be more space than you need.

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.

(continued on the next page)

INFORMATION continued.

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.

There may be spare copies of some diagrams.

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.

Answer ALL questions.

All multiple choice questions must be answered with a cross ☒ 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 Which of the following is the base unit for charge?

☐ **A** As

☐ **B** C

☐ **C** JV^{-1}

☐ **D** Q

(Total for Question 1 = 1 mark)

2 Which of the following could NOT be accelerated in a LINAC?

☐ A electron

☐ B helium atom

☐ C proton

☐ D uranium ion

(Total for Question 2 = 1 mark)

3 Look at the image for Question 3 in the Diagram Booklet. A toy car moves up a slope at a constant speed, as shown. The car is moved by a motor with a power output of 5·2 W. The car gains a gravitational potential energy of 0·40 J in a time of 1·1 s.

Which of the following expressions gives the work done, in J, against resistive forces?

☐ A 5·2 – (0·40 × 1·1)

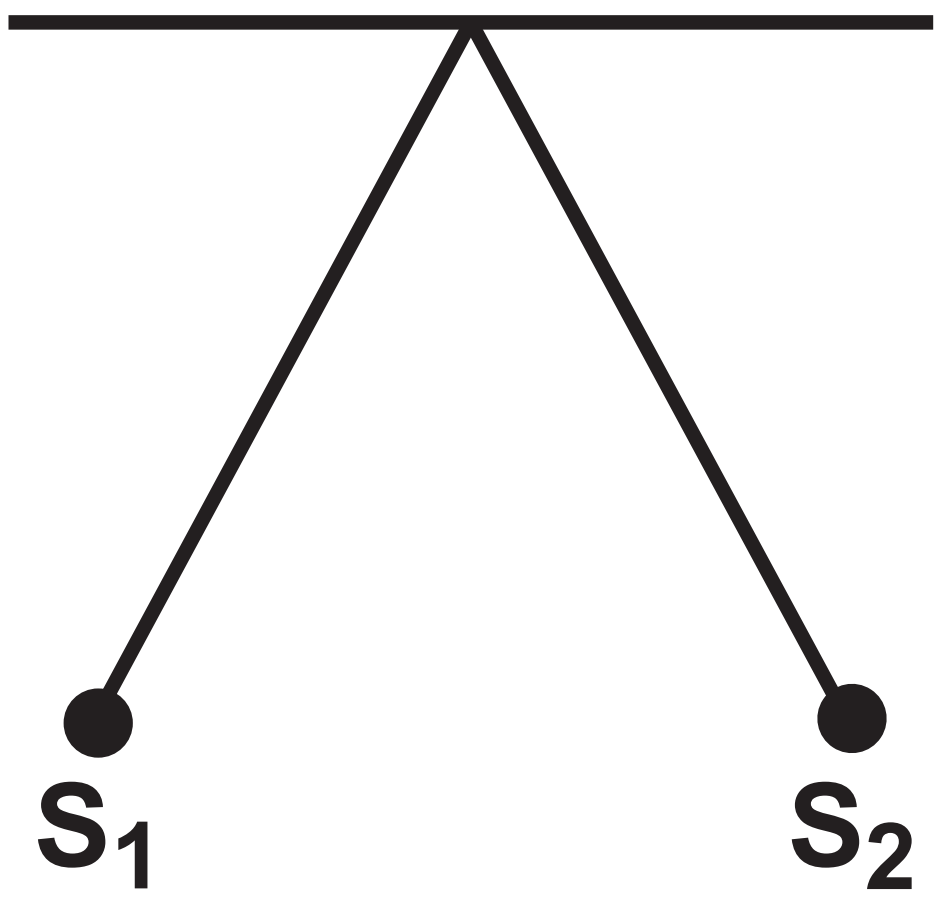
☐ B (5·2 × 1·1) – 0·40

☐ C (5·2 ÷ 1·1) + 0·40

☐ D (5·2 × 1·1) + 0·40

(Total for Question 3 = 1 mark)

Questions 4 and 5 refer to two small positively charged spheres S_1 and S_2 suspended by threads, as shown.



4 Look at the diagrams for Question 4 in the Diagram Booklet. Which of the vector diagrams shows the forces acting on S_2?

- ☐ Diagram A
- ☐ Diagram B
- ☐ Diagram C
- ☐ Diagram D

(Total for Question 4 = 1 mark)

5 The electrostatic force between the two charges is initially F.

The charge on S_1 is doubled whilst the charge on S_2 is unchanged. The distance between S_1 and S_2 doubles.

Which of the following is the new force on S_2?

☐ A $\frac{F}{4}$

☐ B $\frac{F}{2}$

☐ C F

☐ D $2F$

(Total for Question 5 = 1 mark)

6 Look at the diagram for Question 6 in the Diagram Booklet. A square coil has sides of length l and carries a current I, as shown. The plane of the coil is parallel to a magnetic field of flux density B.

Which row of the table gives the magnetic force on the named side of the coil?

	Named side	Magnetic force
☐ A	PQ	BIl to the left
☐ B	QR	BIl to the right
☐ C	RS	BIl upwards
☐ D	SP	BIl downwards

(Total for Question 6 = 1 mark)

7 A length of wire has a non-uniform cross-sectional area. There is an electric current in the wire.

Which of the following is NOT constant along the length of this wire?

☐ A electric current

☐ B electron charge

☐ C electron drift velocity

☐ D number of free electrons per unit volume

(Total for Question 7 = 1 mark)

8 A roundabout completes 5·0 revolutions in 20 s.

Which of the following is the angular velocity of the roundabout?

☐ A $1{\cdot}6\,\text{rad}\,\text{s}^{-1}$

☐ B $16\,\text{rad}\,\text{s}^{-1}$

☐ C $25\,\text{rad}\,\text{s}^{-1}$

☐ D $630\,\text{rad}\,\text{s}^{-1}$

(Total for Question 8 = 1 mark)

9 Look at the diagram for Question 9 in the Diagram Booklet. A person of mass $70\,kg$ is standing on the floor of a lift, as shown. The lift is accelerating downwards at $1{\cdot}5\,m\,s^{-2}$.

Which of the following gives the normal reaction R, in N, acting on the person?

☐ A $R = 70 \times 9{\cdot}81$

☐ B $R = 70 \times 1{\cdot}5$

☐ C $R = (70 \times 9{\cdot}81) + (70 \times 1{\cdot}5)$

☐ D $R = (70 \times 9{\cdot}81) - (70 \times 1{\cdot}5)$

(Total for Question 9 = 1 mark)

10 Look at the diagram for Question 10 in the Diagram Booklet. An object was thrown so that it followed the path shown. Assume drag forces were negligible.

The object was thrown with an initial vertical component of velocity **u**. The time taken to reach maximum height is **t**.

Which of the following could NOT be used to determine the maximum vertical height **s** reached by the object?

☐ **A** $s = ut - \frac{1}{2}gt^2$

☐ **B** $s = ut$

☐ **C** $s = \frac{1}{2}ut$

☐ **D** $s = \frac{u^2}{2g}$

(Total for Question 10 = 1 mark)

11 Look at the image for Question 11 in the Diagram Booklet. A film involves a gang of bank robbers making a getaway on a bus loaded with gold bars. The bus spins out of control and ends up balancing on the edge of a cliff, as shown.

(a) State what is meant by the moment of a force about a point.
(1 mark)

(continued on the next page)

11 continued.

(b) Look at the diagram for Question 11(b) in the Diagram Booklet. The bus is balanced on a pivot that is a distance y from the centre of the bus.

The centre of mass of the gold is $1{\cdot}5\,\text{m}$ from one end of the bus. The centre of mass of the bank robbers is $1{\cdot}0\,\text{m}$ from the other end of the bus, as shown.

The unloaded bus can be treated as a uniform body with a weight of $32\,000\,\text{N}$.

Calculate the distance y when the bus is balanced.
(4 marks)

length of bus = $11{\cdot}0\,\text{m}$
weight of gold bars = $31\,000\,\text{N}$
weight of bank robbers = $8700\,\text{N}$

Answer space continues on the next page.

11(b) continued.

y = _____

(Total for Question 11 = 5 marks)

12 Electrical power is transmitted from Norway to Britain using a cable laid under the North Sea.

The following information is published on a website.

The cable has a diameter of 15 cm and a length of 720 km.

It is made of copper of resistivity $1{\cdot}7 \times 10^{-8}\,\Omega\,\text{m}$.

The electrical power transmitted from Norway is 1400 MW and the transmission potential difference is 1100 kV.

The efficiency of this process is almost 100%.

Deduce, by calculation, whether the claim for efficiency is correct.
(6 marks)

Answer space continues on the next 2 pages.

12 continued.

12 continued.

(Total for Question 12 = 6 marks)

13 Beams of antiprotons are often used in particle physics experiments.

(a) Show that the rest mass of an antiproton is about $900\,\mathrm{MeV}/c^2$.
(4 marks)

Answer space continues on the next page.

13(a) continued.

(continued on the next page)

13 continued.

(b) Antiprotons can be produced by accelerating and colliding two protons moving in opposite directions. A website suggests a possible outcome for a collision between these protons is described by the nuclear equation:

$$p + p \longrightarrow p + p + p + \overline{p}$$

Deduce, by using conservation laws, whether it should be possible to produce an antiproton in this way. (4 marks)

Answer space continues on the next page.

13(b) continued.

(Total for Question 13 = 8 marks)

14 Look at the diagram for Question 14 in the Diagram Booklet. The decay of a positive muon produced a positron, an electron neutrino and a muon antineutrino. The diagram shows the tracks formed in a particle detector.

(a) A muon belongs to a family of particles called leptons.

State two features that all particles in the lepton family have in common. (2 marks)

14 continued.

(b) Write a nuclear equation for the decay of the muon (μ) described above.
(2 marks)

(continued on the next page)

14 continued.

(c) Describe the role of the magnetic field in a particle detector.
(3 marks)

(continued on the next page)

14 continued.

(d) Explain how the diagram gives evidence that a particle or particles, other than the positron, were produced in this decay.
(4 marks)

Answer space continues on the next page.

14(d) continued.

(Total for Question 14 = 11 marks)

15 Look at the diagram for Question 15 in the Diagram Booklet. A teacher demonstrates the electric field produced between two parallel metal plates. The plates are connected to a variable power supply, as shown. The power supply has a very large internal resistance and includes a voltmeter that indicates its output.

(a) (i) Add to the diagram to show the electric field between the two plates.
(3 marks)

(continued on the next page)

15(a) continued.

(ii) Explain why the reading on the voltmeter indicates the e.m.f. of the power supply.
(2 marks)

(continued on the next page)

15 continued.

(b) The power supply output is increased until sparks are heard and are seen in the gap between the plates. Sparks form in air when the electric field strength exceeds $3{\cdot}0 \times 10^{6}\,\mathrm{V\,m^{-1}}$ and the air becomes conducting for a short time.

(continued on the next page)

15(b) continued.

(i) Calculate the minimum potential difference across the plates for sparks to be created.
(2 marks)

distance between parallel plates = 2·0 mm

Minimum potential difference =

(continued on the next page)

15(b) continued.

(ii) Explain why the voltmeter reading decreases significantly whenever sparks are produced. (3 marks)

(Total for Question 15 = 10 marks)

16 A student is investigating circuits that include a filament bulb. The filament bulb is labelled ‘1·5 V, 0·50 W’.

(a) Show that the resistance of the filament bulb when operating normally is about 5 Ω.

(2 marks)

(continued on the next page)

16 continued.

*(b) Look at the circuit for Question 16(b) in the Diagram Booklet. The student wishes to control the brightness of the filament bulb using a potentiometer. The student connects the circuit shown. The total resistance of the potentiometer is very much larger than the resistance of the filament bulb.

Explain how the brightness of the filament bulb changes as the potentiometer slider is moved from **A** to **B**.
(6 marks)

Answer space continues on the next 2 pages.

16(b) continued.

Turn over

16(b) continued.

(continued on the next page)

16 continued.

(c) Look at the circuit for Question 16(c) in the Diagram Booklet. The student connects the filament bulb in the circuit shown. The capacitor is initially uncharged and has a capacitance of $1{\cdot}2\,\mathrm{F}$.

The resistance of the filament bulb is $5\,\Omega$.

Explain how the brightness of the filament bulb will vary as the switch is closed.
(4 marks)

Answer space continues on the next page.

16(c) continued.

(Total for Question 16 = 12 marks)

17 Over one hundred years ago, Rutherford supervised a series of experiments using a source of alpha particles and thin gold foil.

(a) Describe the model of the atom that Rutherford proposed as a result of this series of experiments.

(3 marks)

Answer space continues on the next page.

17(a) continued.

(continued on the next page)

17 continued.

(b) The initial kinetic energy of an alpha $\left({}^{4}_{2}\alpha\right)$ particle is $7{\cdot}3 \times 10^{-13}$ J.

(i) In a textbook, it states that an alpha particle with this energy would be brought to rest when it reached a distance of $5{\cdot}0 \times 10^{-14}$ m

from the centre of the gold nucleus $\left({}^{197}_{79}\mathrm{Au}\right)$.

Deduce whether this statement is correct.
(4 marks)

Answer space continues on the next page.

17(b)(i) continued.

(continued on the next page)

17(b) continued.

(ii) Determine the initial momentum of the alpha particle.
(3 marks)

Initial momentum = _____

(continued on the next page)

17 continued.

(c) Look at the diagram for Question 17(c) in the Diagram Booklet. An alpha particle moves along a path directly towards a gold nucleus, as shown.

(i) An elastic interaction occurs and the alpha particle recoils.

State what is meant by an elastic interaction.
(1 mark)

(continued on the next page)

17(c) continued.

(ii) State what happens to the atoms in the gold foil as a result of these interactions.
(1 mark)

(Total for Question 17 = 12 marks)

18 Look at the diagram for Question 18 in the Diagram Booklet. Regenerative braking supplies a current back to the power transmission system whilst slowing a vehicle. The arrangement shown can be used as a regenerative braking system on a train.

The coil rotates with the wheels of the train. Two copper rings are connected to the ends of the coil. The rings rotate with the coil and two carbon blocks make electrical contact with the rings as they rotate.

(a) Describe how this arrangement can be used as a regenerative brake. (4 marks)

Answer space continues on the next page.

18(a) continued.

(continued on the next page)

18 continued.

(b) A specification for a new train states that the train should be able to accelerate to a speed of $360\,km\,hour^{-1}$ from rest, and that this acceleration should be completed within $40\,km$ of level track.

Look at the graph for Question 18(b) in the Diagram Booklet. It shows the performance of the train on a test run.

(continued on the next page)

18(b) continued.

(i) Calculate the acceleration of the train as it accelerates to a speed of $360\,km\ hour^{-1}$.
(3 marks)

Acceleration of train = _____

(continued on the next page)

18(b) continued.

(ii) Deduce whether the performance of the train met the specification on this test run.
(3 marks)

(continued on the next page)

18 continued.

(c) On curved tracks there is a maximum safe speed for the train.

(i) Explain why there is a maximum safe speed for a train travelling on a curved track.

(4 marks)

Answer space continues on the next page.

18(c)(i) continued.

(continued on the next page)

18(c) continued.

(ii) When the train travels at $200\,km\ hour^{-1}$, the minimum safe radius of curvature of the track is $1800\,m$.

Calculate the minimum safe radius of curvature for a speed of $360\,km\ hour^{-1}$.

(2 marks)

Minimum safe radius of curvature =

(Total for Question 18 = 16 marks)

TOTAL FOR PAPER = 90 MARKS

END OF PAPER