Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Friday 23 May 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **9PH0/01**

Physics

Advanced

PAPER 1: Advanced Physics I

You must have:
Scientific calculator and ruler
Data, Formulae and Relationships Booklet (enclosed)

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.*

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.
- You are advised to show your working in calculations including units where appropriate.

Turn over

Pearson

Answer ALL questions.

All multiple choice questions must be answered with a cross in the box ☒ 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 was investigated by the large-angle alpha particle scattering experiment?

☒ **A** structure of an atom

☒ **B** structure of a nucleon

☒ **C** structure of a nucleus

☒ **D** structure of a quark

(Total for Question 1 = 1 mark)

2 Which of the following is a scalar quantity?

☒ **A** charge

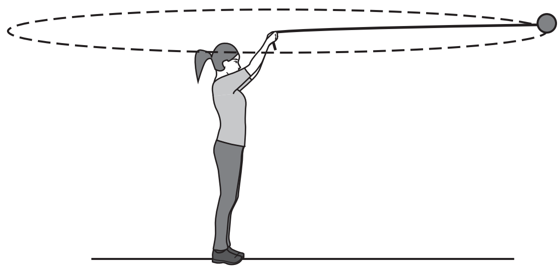
☒ **B** displacement

☒ **C** electric field strength

☒ **D** force

(Total for Question 2 = 1 mark)

3 A ball is tied to the end of a length of string. A person holds the other end of the string. The person spins the ball and string around in a horizontal circle, as shown.



Which of the following statements best describes why the person feels a force from the string?

☒ **A** There is a centripetal force acting on the person.

☒ **B** There is a force on the person due to Newton's first law.

☒ **C** There is a force on the person due to Newton's third law.

☒ **D** There is a force on the person due to the weight of the ball.

(Total for Question 3 = 1 mark)

4 A wire of resistance R has a circular cross-sectional area.

A second wire has the same length and is made of the same material. The diameter of the second wire is double the diameter of the first wire.

Which of the following is the resistance of the second wire?

☒ **A** $4R$

☒ **B** $2R$

☒ **C** $\frac{R}{2}$

☒ **D** $\frac{R}{4}$

(Total for Question 4 = 1 mark)

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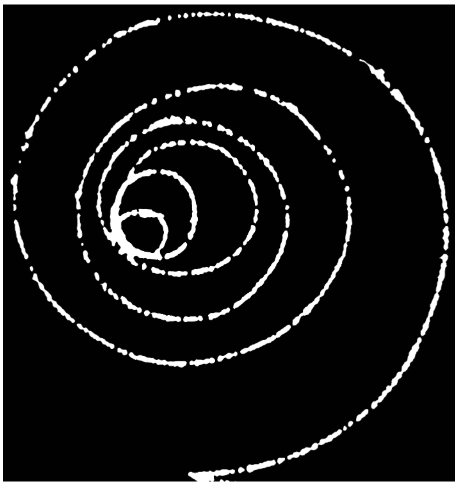
5 A positron produced a track in a detector, as shown.



(Source: © Science Source/SCIENCE PHOTO LIBRARY)

Which of the following is the direction of the magnetic field in this detector?

☒ **A** down the page

☒ **B** into the page

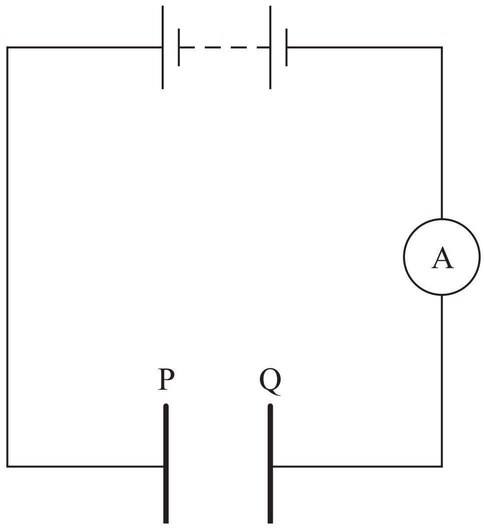
☒ **C** out of the page

☒ **D** up the page

(Total for Question 5 = 1 mark)

Questions 6 and 7 refer to the information below.

A high-voltage d.c. power supply was connected to two parallel metal plates and an ammeter, as shown.



6 The distance between the two plates was decreased.

Which row of the table is correct?

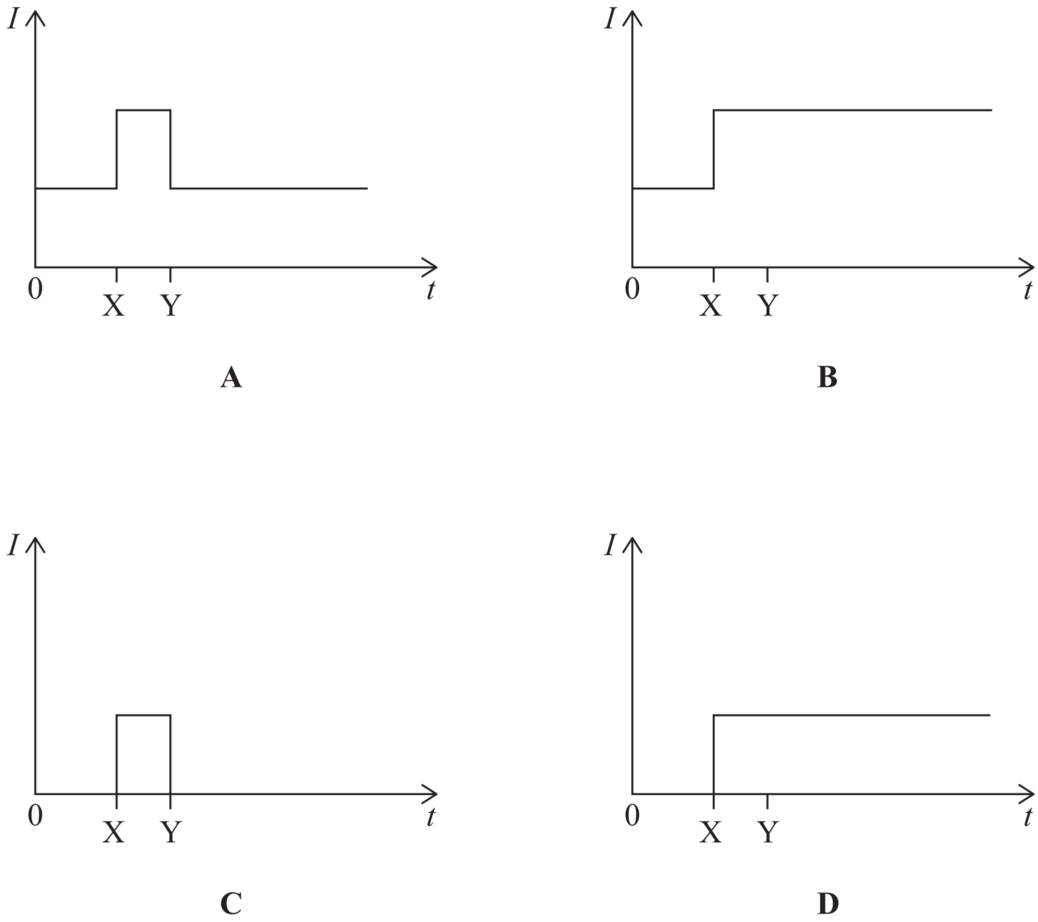
	Direction of electric field	Change in electric field strength
☒ **A**	P to Q	decreased
☒ **B**	Q to P	decreased
☒ **C**	P to Q	increased
☒ **D**	Q to P	increased

(Total for Question 6 = 1 mark)

7 Decreasing the distance between the two plates increases the capacitance of the two parallel plates.

The separation was decreased at time X. At time Y the separation became constant.

Which of the following graphs shows how the reading *I* on the ammeter changed with time *t*?



☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

8 The initial potential difference (p.d.) across a capacitor is V_0. The capacitor is discharged through a resistor. The p.d. across the capacitor decreases to $\frac{V_0}{3}$ in 2 milliseconds.

Which of the following is equal to the time constant, in milliseconds, for this capacitor-resistor circuit?

☒ **A** $\frac{\ln 3}{2}$

☒ **B** $\frac{2}{\ln 3}$

☒ **C** 3

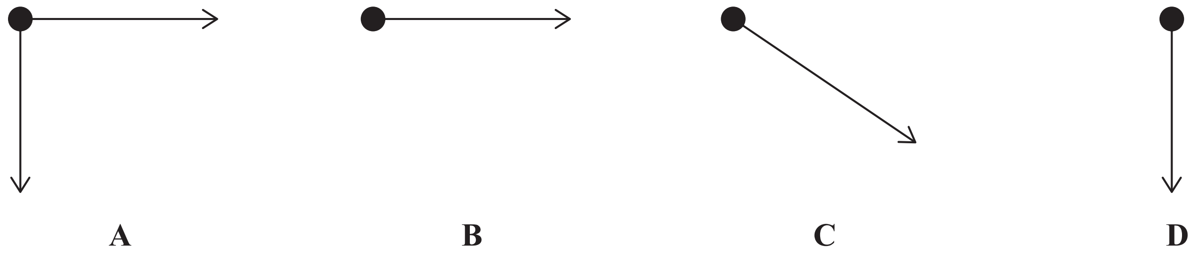
☒ **D** $\frac{2}{3}$

(Total for Question 8 = 1 mark)

Questions 9 and 10 refer to the information below.

A ball was thrown so that it followed the path shown. Assume drag forces were negligible.

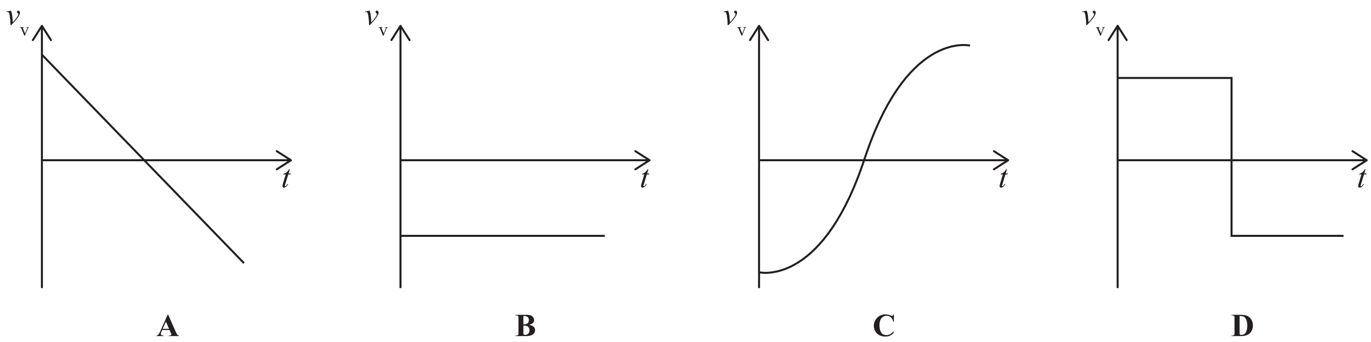
9 Which of the following is a free-body force diagram for the ball at its maximum height?



- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 9 = 1 mark)

10 Which of the following graphs shows how the vertical component of the velocity, v_v, varies with time t from when the ball is thrown to just before it hits the ground?



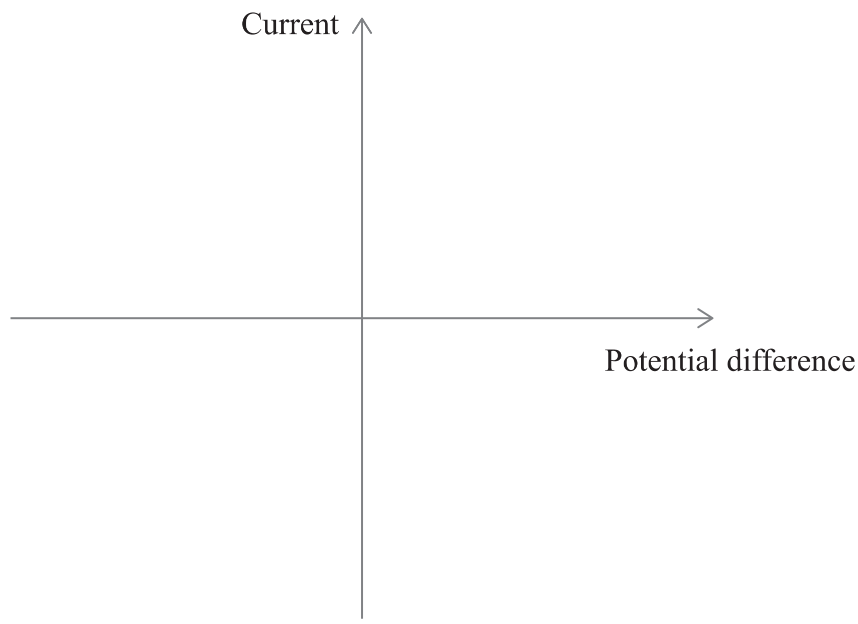
- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 10 = 1 mark)

11 Diodes are used in a variety of electrical circuits.

(a) Sketch the current-potential difference graph for a diode.

(2)



(b) A package containing a light emitting diode (LED) is marked

"20 mA 3.2 V to operate normally".

A student uses a 5 V power supply of negligible internal resistance to operate the LED.

Calculate the resistance of a protective resistor required to operate the LED normally from this power supply.

(3)

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Resistance = ...

(Total for Question 11 = 5 marks)

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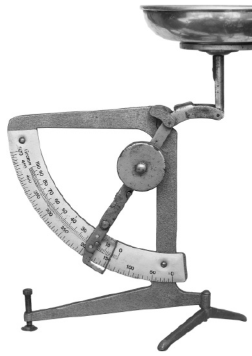
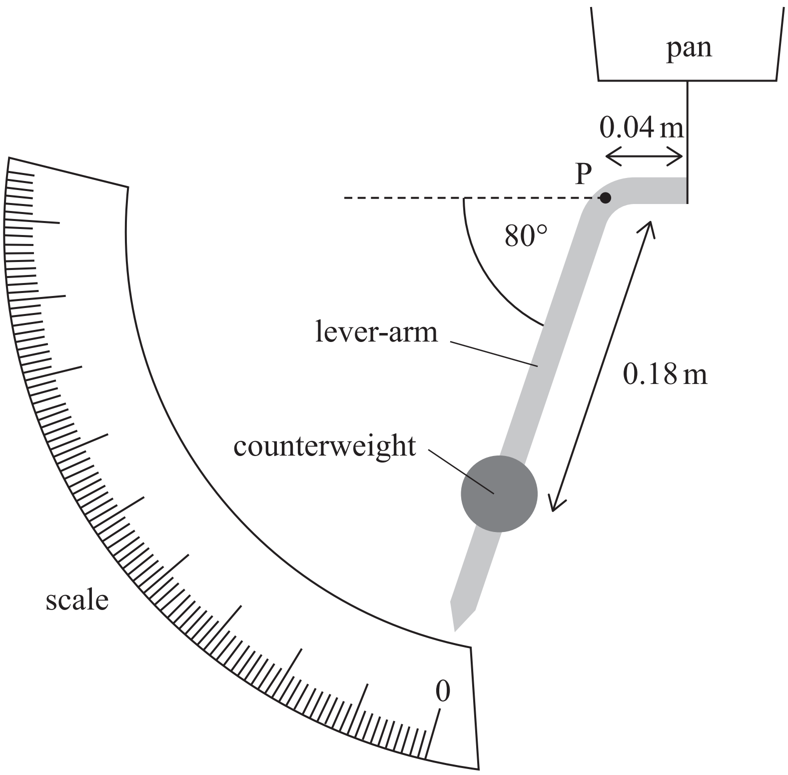
12 The photograph shows a lever-arm balance. The balance can be used to measure the mass of objects to the nearest gram.



(Source: © sasaperic/Getty Images)

The lever-arm is a length of metal, bent at one end as shown in the diagram below. The lever-arm can rotate around the pivot, P.



The arrangement is in equilibrium.

(a) State the two conditions needed for the arrangement to be in equilibrium.

(2)

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(b) Determine the weight of the counterweight.

Assume the mass of the lever-arm is negligible.

mass of pan = 260 g

(4)

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Weight of counterweight = ...

(c) An object is placed in the pan. The lever-arm moves along the scale.

Explain why the lever-arm pointer moves through a large distance whilst the pan moves a much shorter distance.

(2)

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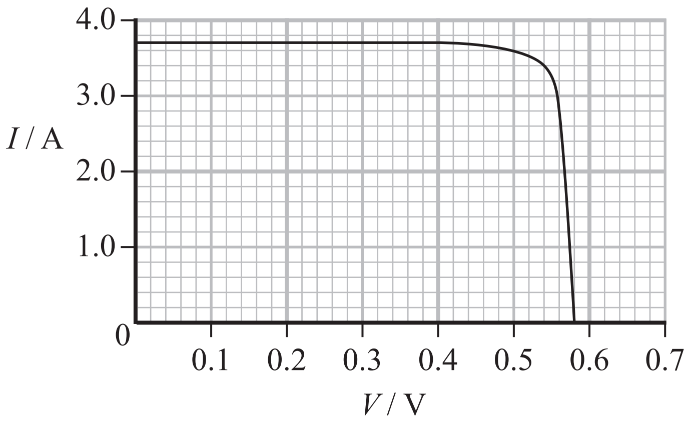
(Total for Question 12 = 8 marks)

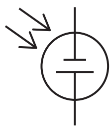
13 Solar cells are being used in increasing numbers around the world.

The current I from a solar cell can be varied by connecting it to a variable resistor. The graph shows how I and the terminal potential difference V across a solar cell vary.



(a) Complete the circuit diagram below to show how the data for the graph could be obtained.

(2)



(b) (i) Show that the maximum power output from the solar cell is about 2 W. You should use values from the graph.

(2)

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(ii) The area of the solar cell is $104\,\text{cm}^2$.

Determine the efficiency of the solar cell when operating at maximum power.

intensity of sunlight = $1000\,\text{W}\,\text{m}^{-2}$

(3)

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Efficiency = ...

(iii) Calculate the internal resistance of the solar cell when operating at maximum power.

(3)

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Internal resistance = ...

(Total for Question 13 = 10 marks)

14 Flowers can attract bees by being colourful or by producing a scent. Some flowers also attract bees by producing an electric field.

(a) Draw the electric field around a negative point charge.

(2)

(b) When a bee gets close to a flower it can detect the electric field. The charge on the flower acts as a point charge at the centre of the flower.

(i) At a distance of 0.06 m from the centre of a particular flower the potential is –16 V.

Show that the charge on this flower is about –0.1 nC.

(3)

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(ii) The minimum field strength that a bee can detect is $120\,\mathrm{V\,m^{-1}}$.

A teacher suggests that bees can detect the field when they are closer than 10 cm from the flower in (b)(i).

Deduce whether this suggestion is correct.

(3)

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(c) It is suggested that the hairs on a bee deflect slightly when close to the flower.

Explain what would cause a hair to deflect in an electric field.

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(Total for Question 14 = 10 marks)

15 A sigma (Σ^+) particle is a baryon. It can decay into a positive pion and a neutron.

(a) Complete the particle equation for this decay.

(2)

$\Sigma^+ \rightarrow$

(b) Explain whether the conservation laws of charge and baryon number are obeyed for this decay.

(2)

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(c) The table summarises the charges for three types of quark.

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

The sigma particle has one strange quark within its structure.

Deduce the quark structure for Σ^+

(2)

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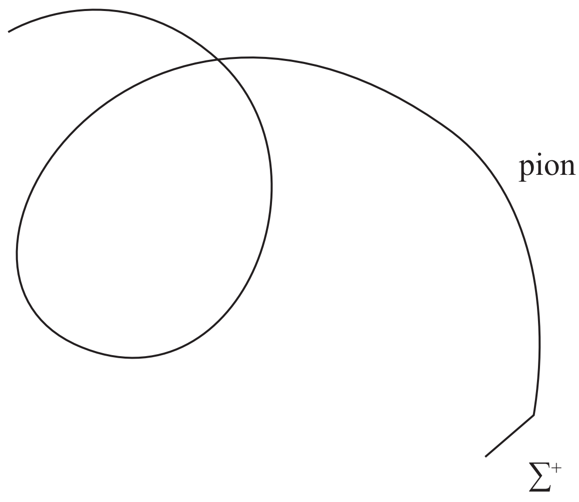
(d) The diagram shows tracks in a particle detector associated with this decay.



(i) State why the neutron does not leave a track.

(1)

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(ii) The initial momentum of the positive pion is 1.1×10^{-19} N s. The scale of the diagram is 1 cm represents 15 cm.

Determine the magnitude of the magnetic flux density acting perpendicularly to the tracks.

(4)

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Magnetic flux density = ...

(Total for Question 15 = 11 marks)

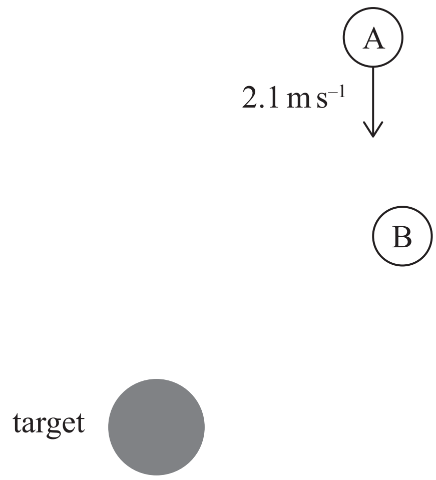
16 Curling is a sport played on ice. Players slide stones made of granite along the ice. The aim of the sport is to slide a stone into a circular area called the target.

The diagram below shows two stones, A and B. Each stone has a mass of 18 kg.

Stone A is moving with a velocity of $2.1\,m\,s^{-1}$, as shown. B is initially stationary.

Not to scale

View from above



(a) (i) Show that the momentum of A is about 40 N s.

(2)

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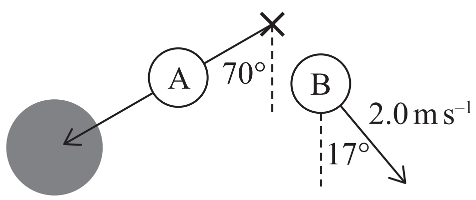
(ii) Stone A collides with stone B.

The diagram below shows the velocity of stone B after the collision. The point of collision is marked ✕.

View from above

Not to scale



Deduce whether stone A moves in the direction shown after the collision.

(5)

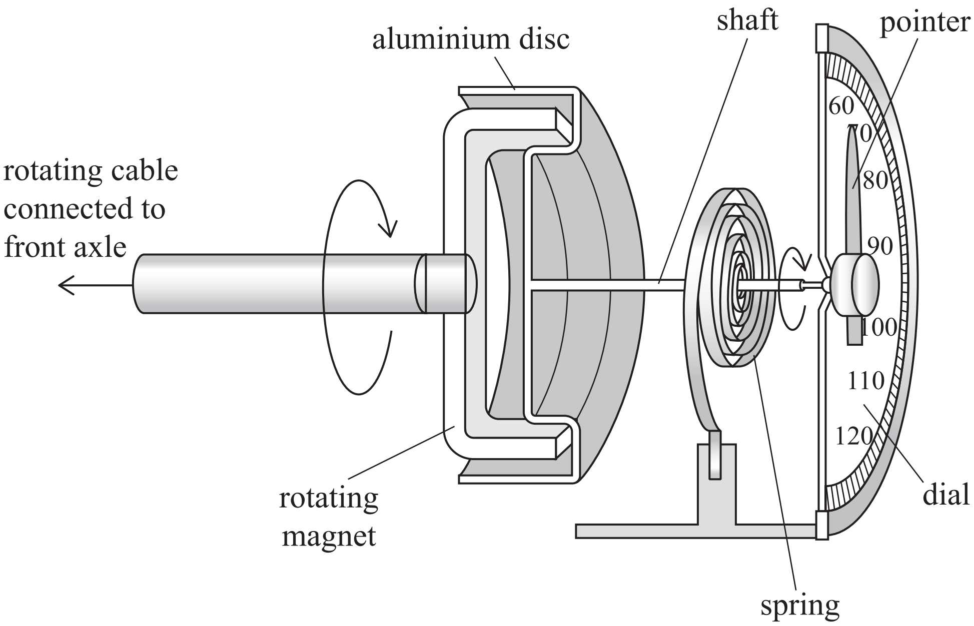
(b) Stone A comes to rest 1.9 m from X. The deceleration of the stone on the ice is $0.10\,\mathrm{m\,s^{-2}}$.

Deduce whether the collision was elastic.

(4)

(Total for Question 16 = 11 marks)

17 The diagram shows a section through the components of a speedometer for a bicycle. The front wheel axle of the bicycle is connected to a cable. The cable rotates as the bicycle wheel rotates. The other end of the cable is connected to a magnet which also rotates, as shown.



An aluminium disc is shaped so that it is close to, but not touching, the magnet. The disc is connected to a pointer by a shaft. A spring prevents the disc and shaft from freely rotating.

*(a) Explain why the aluminium disc rotates in the same direction as the magnet.

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(b) The road speed of the bicycle should be displayed by the speedometer.

Explain why the displayed speed can **not** be accurate, as bicycles can have different wheel diameters.

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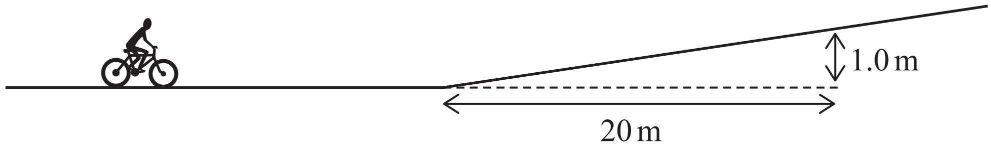
(c) A cyclist has a constant speed of $8.3\,\mathrm{m\,s^{-1}}$ on a flat road. The cyclist generates an average power of 190 W. The total mass of the cyclist and bicycle is 75 kg.

The cyclist comes to a hill of gradient 1 in 20, as shown.



The cyclist now generates an average power of 330 W. The speed decreases to a constant value which the speedometer suggests is $5.6\,\mathrm{m\,s^{-1}}$.

Deduce whether the speedometer is accurate.

Assume resistive forces are constant.

(4)

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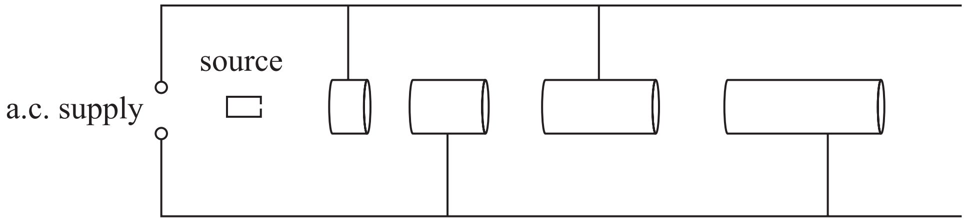
(Total for Question 17 = 12 marks)

18 At the Facility for Rare Isotope Beams (FRIB) isotopes of elements that do not occur naturally can be produced.

(a) FRIB contains a linear accelerator. The initial section of the accelerator is shown.



Explain why the tubes get progressively longer.

(4)

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(b) A uranium atom ($^{238}_{92}U$) has 80 electrons removed. The uranium ion is then accelerated between two adjacent tubes until its kinetic energy is 200 MeV per nucleon.

(i) Calculate the accelerating potential difference.

(4)

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Potential difference = ...

(ii) Show that the uranium ions will reach a velocity of about 65% of the speed of light.

(3)

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(c) When a uranium ion hits a target at this speed the ion is likely to break up and produce smaller elements. One particular isotope produced in this way is $^{40}_{12}\text{Mg}$. The naturally occurring common stable isotope of magnesium is $^{24}_{12}\text{Mg}$.

Explain why the break-up of $^{238}_{92}\text{U}$ is likely to produce unusual isotopes such as $^{40}_{12}\text{Mg}$.

(2)

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(Total for Question 18 = 13 marks)

TOTAL FOR PAPER = 90 MARKS

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Pearson Edexcel Level 3 GCE

Friday 23 May 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **9PH0/01**

Physics

Advanced

PAPER 1: Advanced Physics I

Data, Formulae and Relationships Booklet
Do not return this Booklet with the question paper.

Turn over

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P 7 8 5 2 4 A

Pearson

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 law constant	$k = \dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{N m}^2\ \text{C}^{-2}$	
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	$u = 1.66 \times 10^{-27}\ \text{kg}$	

Mechanics

Kinematic equations of motion

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

$$v = u + at$$

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

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

Forces

$$\Sigma F = ma$$

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

$$W = mg$$

moment of force = Fx

Momentum

$$p = mv$$

Work, energy and power

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

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

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

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

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

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

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

Electric circuits

Potential difference

$$V = \frac{W}{Q}$$

Resistance

$$R = \frac{V}{I}$$

Electrical power and energy

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

$$W = VIt$$

Resistivity

$$R = \frac{\rho l}{A}$$

Current

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nqvA$$

Materials

Density

$$\rho = \frac{m}{V}$$

Stokes' law

$$F = 6\pi\eta rv$$

Hooke's law

$$\Delta F = k\Delta x$$

Young modulus

$$\text{Stress } \sigma = \frac{F}{A}$$

$$\text{Strain } \varepsilon = \frac{\Delta x}{x}$$

$$E = \frac{\sigma}{\varepsilon}$$

Elastic strain energy

$$\Delta E_{el} = \tfrac{1}{2}F\Delta x$$

Waves and particle nature of light

Wave speed

$$v = f\lambda$$

Speed of a transverse wave on a string

$$v = \sqrt{\frac{T}{\mu}}$$

Intensity of radiation

$$I = \frac{P}{A}$$

Power of a lens

$$P = \frac{1}{f}$$

$$P = P_1 + P_2 + P_3 + \ldots$$

Thin lens equation

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Magnification for a lens

$$m = \frac{\text{image height}}{\text{object height}} = \frac{v}{u}$$

Diffraction grating

$$n\lambda = d \sin \theta$$

Refractive index

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$n = \frac{c}{v}$$

Critical angle

$$\sin C = \frac{1}{n}$$

Photon model

$$E = hf$$

Einstein's photoelectric equation

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

de Broglie wavelength

$$\lambda = \frac{h}{p}$$

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

$$v = \omega r$$

$$T = \frac{2\pi}{\omega}$$

$$F = ma = \frac{mv^2}{r}$$

$$a = \frac{v^2}{r}$$

$$a = r\omega^2$$

$$F = mr\omega^2$$

Fields

Coulomb's law

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

Electric field strength

$$E = \frac{F}{Q}$$

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$E = \frac{V}{d}$$

Electric potential

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

Capacitance

$$C = \frac{Q}{V}$$

Energy stored in a capacitor

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

$$W = \tfrac{1}{2}CV^2$$

$$W = \frac{1}{2}\frac{Q^2}{C}$$

Capacitor discharge

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

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

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

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

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

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

In a magnetic field

$$F = BIl \sin\theta$$

$$F = Bqv \sin\theta$$

Faraday's and Lenz's laws

$$\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$$

Root-mean-square values

$$V_{\mathrm{rms}} = \frac{V_0}{\sqrt{2}}$$

$$I_{\mathrm{rms}} = \frac{I_0}{\sqrt{2}}$$

Nuclear and particle physics

In a magnetic field

$$r = \frac{p}{BQ}$$

Thermodynamics

Heating

$$\Delta E = mc\Delta\theta$$

$$\Delta E = L\Delta m$$

Molecular kinetic theory

$$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$$

$$pV = \frac{1}{3}Nm\langle c^2\rangle$$

Ideal gas equation

$$pV = NkT$$

Stefan-Boltzmann law

$$L = \sigma AT^4$$

$$L = 4\pi r^2\sigma T^4$$

Wien's law

$$\lambda_{max}T = 2.898 \times 10^{-3} \text{ m K}$$

Space

Intensity

$$I = \frac{L}{4\pi d^2}$$

Redshift of electromagnetic radiation

$$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$$

Cosmological expansion

$$v = H_0 d$$

Nuclear radiation

Mass-energy

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

Radioactive decay

$$A = \lambda N$$

$$\frac{dN}{dt} = -\lambda N$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N = N_0 \, e^{-\lambda t}$$

$$A = A_0 \, e^{-\lambda t}$$

Gravitational fields

Gravitational force

$$F = \frac{Gm_1m_2}{r^2}$$

Gravitational field strength

$$g = \frac{Gm}{r^2}$$

Gravitational potential

$$V_{grav} = \frac{-Gm}{r}$$

Oscillations

Simple harmonic motion

$$F = -kx$$

$$a = -\omega^2 x$$

$$x = A\cos\omega t$$

$$v = -A\omega\sin\omega t$$

$$a = -A\omega^2\cos\omega t$$

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$\omega = 2\pi f$$

Simple harmonic oscillator

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

END OF DATA, FORMULAE AND RELATIONSHIPS LIST

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