Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Pearson Edexcel Level 3 GCE

Tuesday 17 June 2025

Morning (Time: 2 hours 30 minutes)

Paper reference **9PH0/03**

Physics

Advanced

PAPER 3: General and Practical Principles in Physics

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 120.
- 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 questions 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.

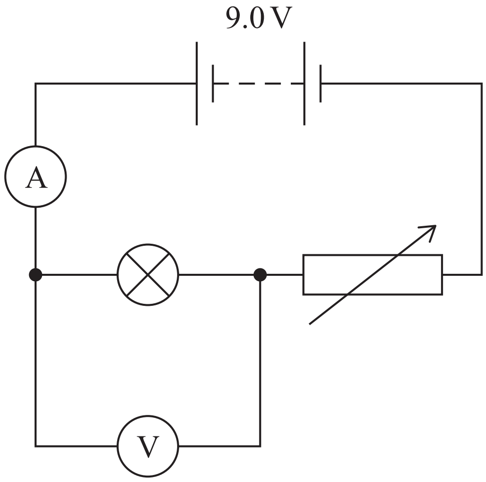
Turn over ▶

Pearson

Answer ALL questions in the spaces provided.

1 A student investigated the variation of current with applied potential difference (p.d.) for a filament bulb. Under normal working conditions the potential difference across the bulb is 3.0 V.

(a) The circuit diagram shows the circuit the student used.



Comment on the suitability of the student's circuit.

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(b) When the p.d. across the bulb was 3.0 V, the student recorded a value of 1.29 A for the current.

In his conclusion he stated

> This will give an accurate value for the working resistance, as the value of current is precise.

Assess the validity of the student's statement. You do not need to carry out a calculation.

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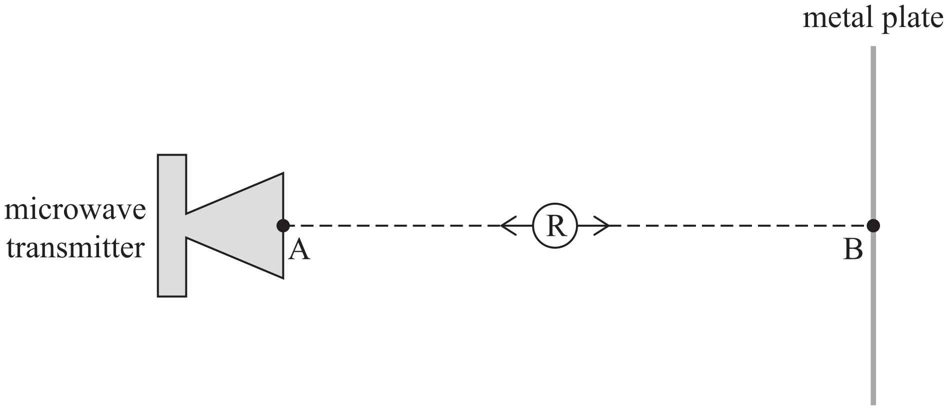
(Total for Question 1 = 7 marks)

2 A transmitter produces microwaves with a frequency of 10.7 GHz. The microwaves are directed towards a metal plate. A microwave receiver R is placed between the transmitter and the metal plate, as shown.



When R is moved along the line AB, the intensity of microwaves received is observed to increase from minimum to maximum a number of times. The distance between successive minima is about 1.5 cm.

Explain these observations. Your answer should include a calculation.

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(Total for Question 2 = 5 marks)

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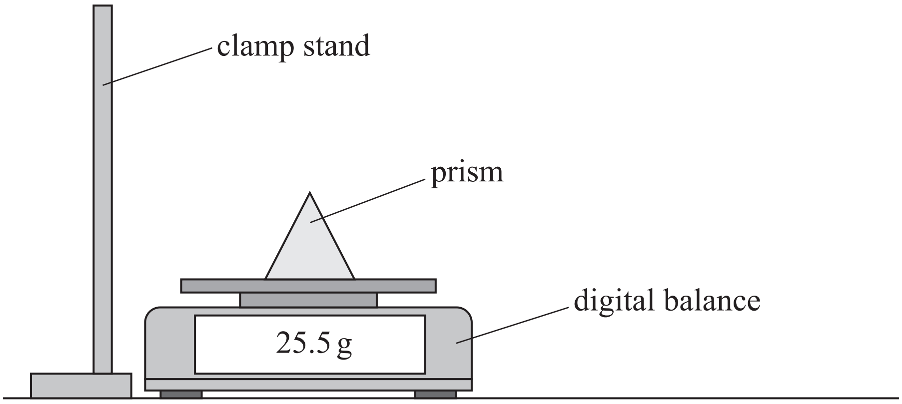
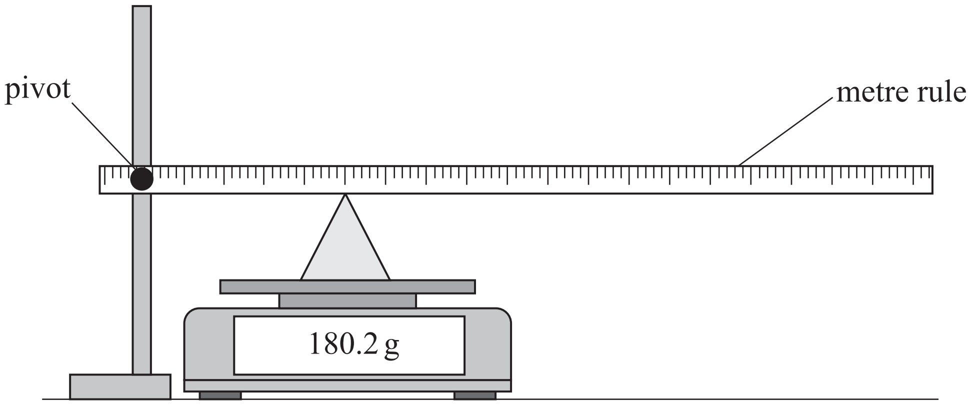
3 A student uses a digital balance. She sets the balance to zero and then places a prism on the balance, as shown.



A uniform metre rule is pivoted at its 5.0 cm mark. The metre rule is then supported horizontally at the 30.0 cm mark by the prism, as shown below.



(a) (i) The metre rule is in equilibrium.

Explain why the increase in mass recorded by the balance is not equal to the mass of the metre rule.

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(ii) Calculate the weight of the metre rule. You should take moments about the pivot.

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Weight of metre rule = ...

(b) The student wants to reduce the percentage uncertainty in the value obtained for the weight of the metre rule.

The student repeated her determination of the weight of the metre rule. She moved the prism towards the centre of gravity of the metre rule before taking moments about the pivot.

Deduce whether the percentage uncertainty in the value obtained for the weight of the metre rule is reduced by the student moving the prism. No calculations are required.

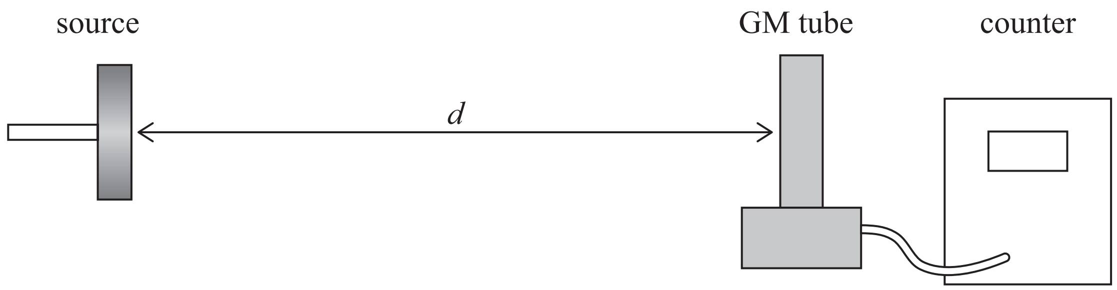
(3)

(Total for Question 3 = 9 marks)

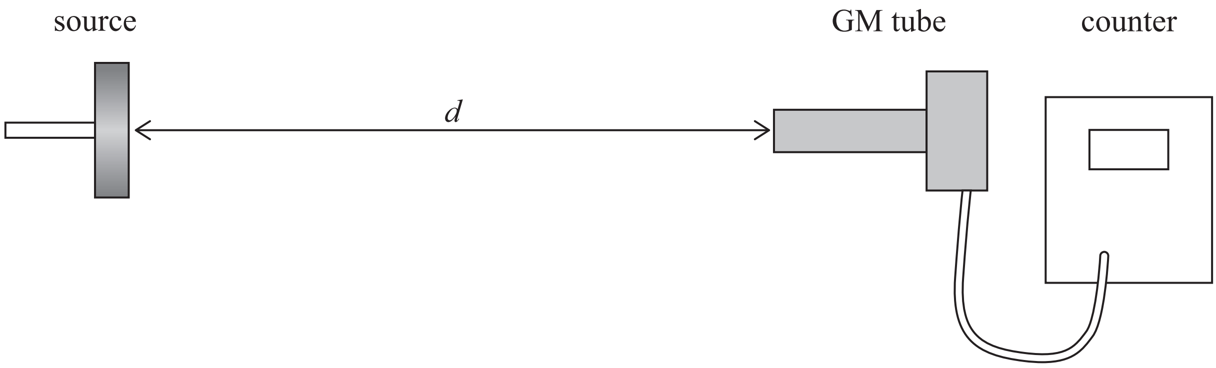
4 Two students, A and B, used a cobalt-60 source to investigate the inverse square law for a gamma radiation source. Cobalt-60 is a pure gamma emitter.

(a) The cobalt-60 source was placed in a source holder. A Geiger-Müller (GM) tube was connected to a counter and placed a short distance *d* away.

(i) Student A set up the apparatus as shown.



Student B used the same distance *d* but rotated the GM tube by 90°, as shown below.



Both students recorded the count for 2 minutes.

Deduce which set-up will lead to a smaller percentage uncertainty in the count rate.

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P 7 8 5 2 2 A 0 8 3 2

(ii) Explain two modifications to the experimental method which would improve the accuracy of the data.

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(b) Student A suggests that the investigation into the inverse square law for a gamma radiation source could be carried out successfully using a radium-226 source.

Radium-226 emits alpha and beta radiation as well as gamma radiation.

Explain **one** modification that would be necessary if a radium-226 source were to be used.

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(Total for Question 4 = 9 marks)

5 Fuse wire is made of a metal that has a low melting point. The wire melts when the current exceeds a maximum value.

A student investigated how the cross-sectional area affected the current at which a wire melted. She used wires of the same length and metal, but different diameters.

The student steadily increased the current through each wire and recorded the maximum current through the wire before it melted.

(a) Describe how the student could determine an accurate value for the cross-sectional area of a wire.

(4)

(b) (i) Explain why a current in a wire causes the resistance of the wire to change.

(3)

(ii) The length of a wire does not affect the value of current at which the wire melts.

Explain why. Assume the wire behaves as a black body.

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(Total for Question 5 = 9 marks)

***6** Air at room temperature was sealed in a closed container. The container was placed in an ice bath and the temperature of the air decreased. The volume of the container remained constant.

Explain what happened to the pressure exerted by the air. In your response you should refer to the momentum of the air molecules.

(Total for Question 6 = 6 marks)

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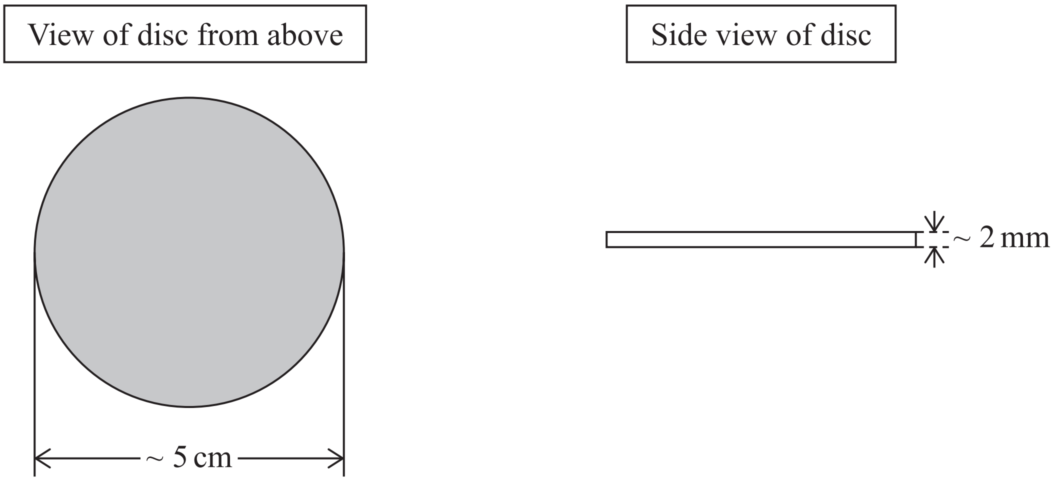
7 A student has 10 identical flat metal discs. One of the discs is shown. Each disc has a diameter d of about 5 cm and a thickness t of about 2 mm.



The student determined the density of the metal the discs are made from.

She used a half-metre rule to measure d for one of the discs. She used vernier calipers to measure t for one of the discs.

The student then repeated this process for two more discs and calculated average values for d and t of the discs.

(a) Describe improvements to the student's method that would give more accurate values for d and t of the discs.

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(b) The student determined the average mass of a disc to be 42.5 g ± 0.5 g.

Calculate the density of the material the discs are made from and the percentage uncertainty in this value.

average diameter of disc = 5.2 cm ± 0.1 cm
average thickness of disc = 1.9 mm ± 0.1 mm

(6)

Density = ...

Percentage uncertainty = ...

(Total for Question 7 = 10 marks)

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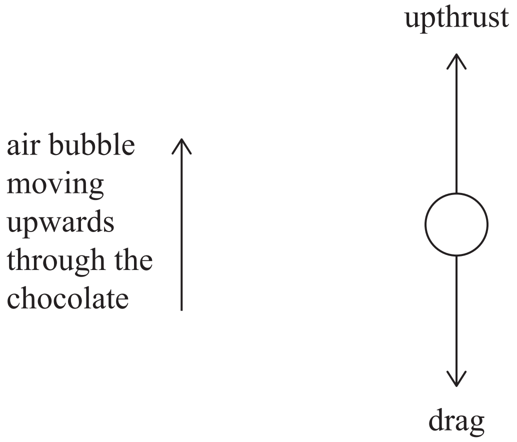
8 An object moving through a fluid experiences a drag force due to the viscosity of the fluid.

(a) Some liquid chocolate is poured into a mould. Within the chocolate a bubble of air is formed. The bubble has negligible weight and moves upwards at a constant speed, as shown.



Calculate the constant speed at which the air bubble moves upwards in the liquid chocolate.

radius of air bubble = 6.8×10^{-3} m
density of liquid chocolate = 925 kg m^{-3}
viscosity of liquid chocolate = 52.6 Pa s

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Speed air bubble moves upwards = ...

(b) The viscosity of a gas increases with temperature.

(i) It is suggested that the relationship between viscosity η and temperature T is of the form

$$\eta = AT^B$$

where A and B are constants.

Explain why a graph of log η against log T would give a straight line.

(2)

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(ii) The table shows data for the viscosity of hydrogen gas over a range of temperatures.

T / K	η / mPa s		
123	4.60		
173	6.00		
273	8.30		
373	10.4		
473	12.0		

Plot a graph of log η against log T. You should use the columns provided to show any processed data.

(5)

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(iii) Determine values for A and B. You are not required to state the units of A.

(4)

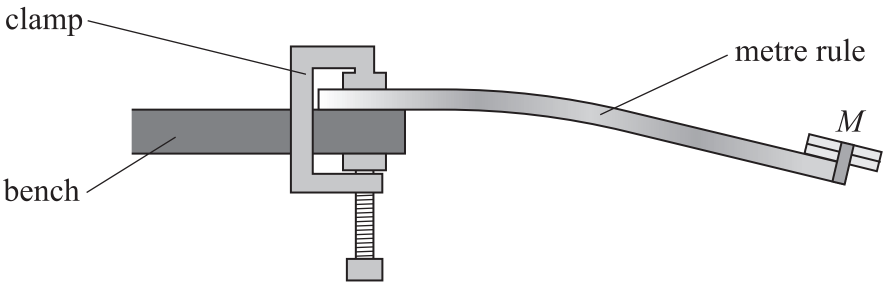
$A =$ ....

$B =$ ....

(Total for Question 8 = 16 marks)

9 A cantilever is a beam fixed at one end.

A student made a cantilever by clamping a metre rule to a bench and attached a mass M at the free end, as shown.



The student displaced the free end through a small distance. When the free end was released, the cantilever oscillated with simple harmonic motion of period T.

(a) The student measured the time for 5 oscillations with an electronic stopwatch. This was repeated twice.

(i) Explain **one** modification to the apparatus which would improve the accuracy of the data the student obtained.

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(ii) Explain **one** modification to the student's method which would reduce the percentage uncertainty in her measurement of T.

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(b) The length of the metre rule overhanging the bench was L. The period of oscillation T is related to L, M and the Young modulus E of the wood of the metre rule by the expression

$$T^2 \propto \frac{ML^3}{E}$$

The student repeated the timing measurements for a half-metre rule.

The half-metre rule had the same added mass M, width and thickness as the metre rule.

The metre rule was made from wood of Young modulus E_1, and the half-metre rule was made from wood of Young modulus E_2.

The student collected the following data.

			Time for 5 oscillations		
	Young modulus	**L / m**	**t_1 / s**	**t_2 / s**	**t_3 / s**
Metre rule	E_1	0.95	14.69	14.64	14.76
Half-metre rule	E_2	0.45	5.33	5.40	5.24

The table below gives the Young modulus values of various types of wood.

Type of wood	Cedar	Spruce	Pine
Young modulus / GPa	7.7	9.6	10.1

Deduce the type of wood each rule is made from.

(6)

(Total for Question 9 = 11 marks)

10 The potential difference (p.d.) from a power pack alternates at a frequency of 50 Hz. The root-mean-square (r.m.s.) value of the output p.d. is measured to be 8.5 V using an a.c. voltmeter.

The output from the power pack is connected to a resistor of resistance 1.5 Ω.

(a) Show that the rate of power dissipation in the resistor is about 48 W.

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(b) A lab technician used the resistor to heat $1.25 \times 10^{-4}\,\text{m}^3$ of milk in a beaker.

Calculate the time taken for the milk to increase in temperature by 12 °C.

specific heat capacity of milk = $3930\,\text{J}\,\text{kg}^{-1}\,\text{K}^{-1}$
density of milk = $1050\,\text{kg}\,\text{m}^{-3}$

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Time = ...

(c) The lab technician used an oscilloscope to determine the supply frequency and check the r.m.s. output p.d. displayed by the voltmeter.

Describe the methods the technician should use.

(6)

(Total for Question 10 = 12 marks)

11 Particle accelerators produce beams of high speed charged particles which are used to investigate particle collisions. New particles are created during the collisions.

(a) In the Large Hadron Collider (LHC), protons are maintained in a circular path by the force exerted on the protons due to a magnetic field.

(i) The magnetic flux density required to maintain the protons in a circular path increases as the kinetic energy of the protons increases.

Explain why.

(2)

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(ii) Calculate the magnetic flux density required to maintain the protons in the LHC when the protons are travelling at a speed of $3.0 \times 10^7 \, \text{m s}^{-1}$.

circumference of LHC = 27 km

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Magnetic flux density = ...

(iii) A maximum of 13 600 GeV of energy is available to create a new particle.

Calculate the theoretical maximum mass, in kg, of the new particle.

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Maximum mass = ... kg

*(b) Fifty years ago, fixed-target collision experiments were carried out at the Stanford Linear Accelerator Centre (SLAC). In these experiments, high speed particles were made to collide with a stationary target.

Currently, colliding beam experiments are carried out at SLAC. In these experiments, high speed particles travelling in opposite directions are made to collide head-on.

For a given total energy in the collision, colliding beam experiments allow particles to be created with a larger mass than could be created in a fixed-target experiment.

Explain why colliding beam experiments allow a new particle with the larger mass to be created. You should consider how the conservation of energy and the conservation of momentum apply to each type of collision.

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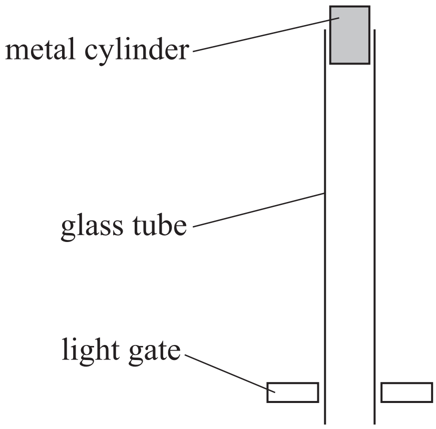
(Total for Question 11 = 15 marks)

12 In an experiment to determine the acceleration of free-fall, g, a metal cylinder was dropped from rest down a glass tube. A light gate was positioned close to the outside of the glass tube, as shown.



The light gate was connected to a data logger that recorded the time t taken for the cylinder to pass the gate.

(a) A student recorded the following data.

t_1 / ms	t_2 / ms	t_3 / ms	t_4 / ms
7.85	7.81	7.79	7.80

(i) The student omitted t_1 when calculating the mean time. He justified this by stating that t_1 is an anomalous result.

Another student stated that the correct mean time should use all the data in the table.

Explain who is correct.

(2)

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(ii) Calculate the percentage uncertainty in the mean time t_{mean}.

(3)

Percentage uncertainty in t_{mean} = ...

(iii) The student used the mean time to calculate the velocity of the metal cylinder as it moved past the light gate.

State the extra measurement the student must have made to calculate this velocity.

(1)

(b) The metal cylinder fell through a distance 0.75 m before reaching the light gate.

(i) Calculate the velocity of the metal cylinder as it reached the light gate.

(2)

Velocity = ...

(ii) Explain why a light gate and data logger were used in this experiment rather than a stopwatch. You should refer to your answer to (b)(i).

(3)

(Total for Question 12 = 11 marks)

TOTAL FOR PAPER = 120 MARKS

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Pearson Edexcel Level 3 GCE

Tuesday 17 June 2025

Morning (Time: 2 hours 30 minutes)

Paper reference	**9PH0/03**

Physics

Advanced

PAPER 3: General and Practical Principles in Physics

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

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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

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

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

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

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

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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