Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number

Candidate Number

Pearson Edexcel International Advanced Level

Friday 27 October 2023

Morning (Time: 1 hour 20 minutes)

Paper reference **WPH16/01**

Physics

International Advanced Level
UNIT 6: Practical Skills in Physics II

You must have:
Scientific calculator, ruler

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 50.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The list of data, formulae and relationships is printed at the end of this booklet.

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 ▶

Pearson

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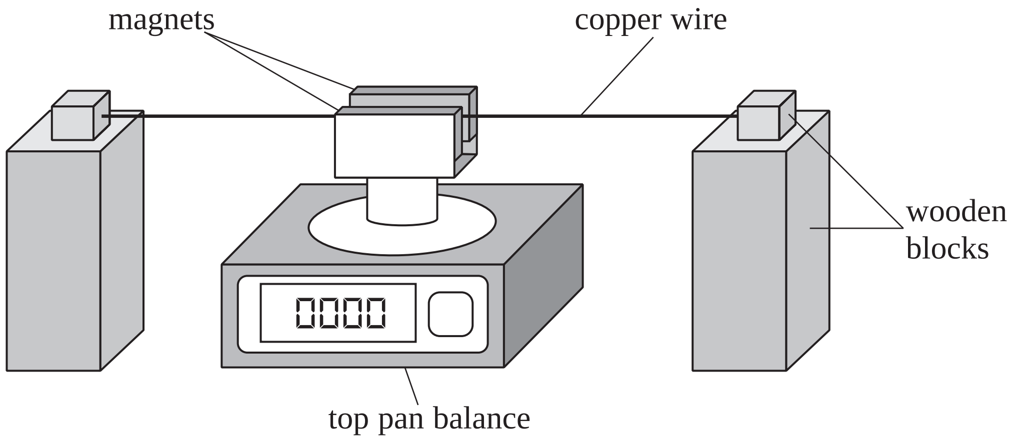
Answer ALL questions.

1 A student investigated the force on a current-carrying wire in a magnetic field. He used the apparatus shown.



The student connected the copper wire to a circuit which included a power supply with a fixed potential difference. The maximum current from the power supply was 5A.

The student increased the current I in the copper wire. He recorded each corresponding reading m from the top pan balance.

(a) Describe one safety issue and how it should be dealt with.

(2)

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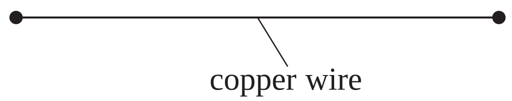
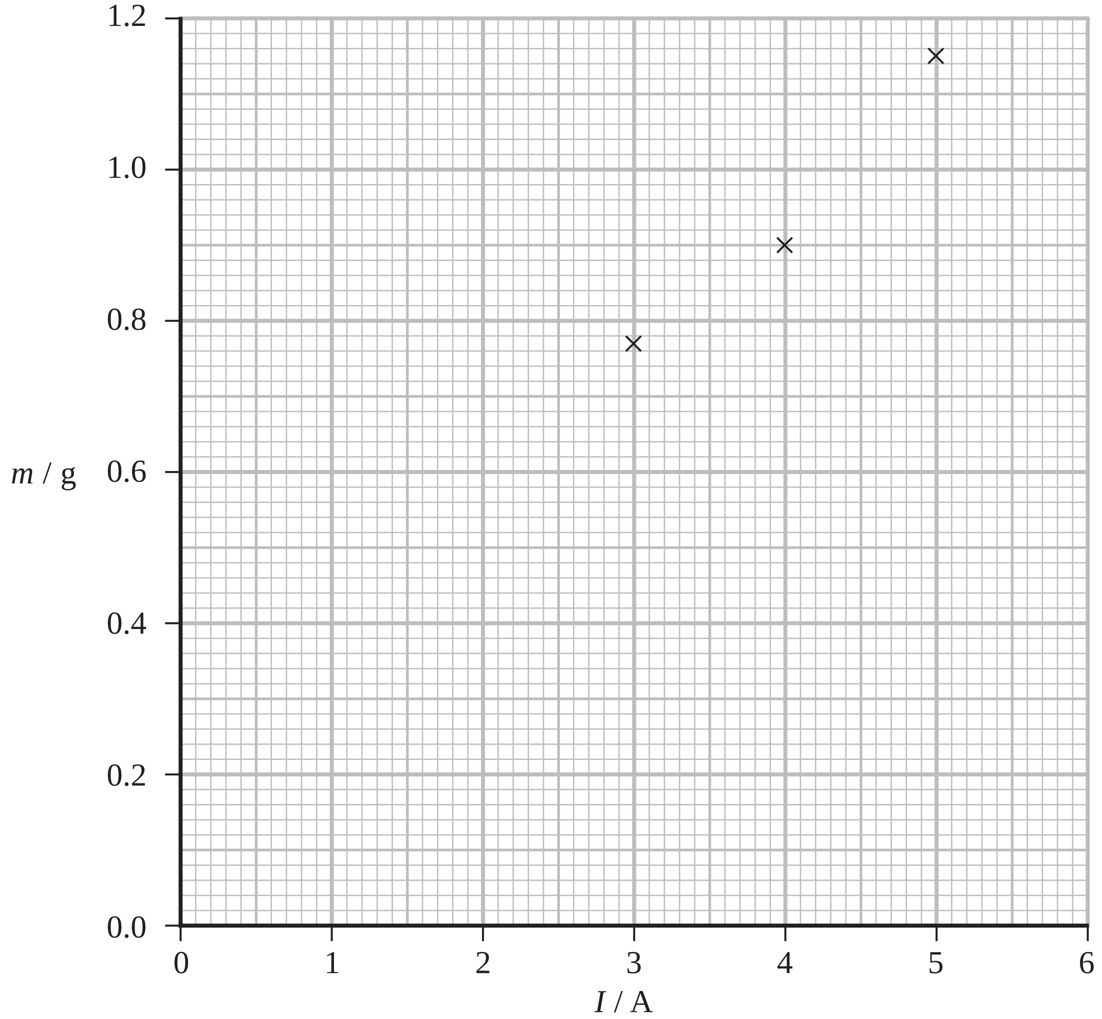
(b) Complete the circuit diagram for this investigation.

(2)



(c) The student plotted a graph of his readings as shown.



The relationship between *m* and *I* is given by

$$m = \left(\frac{BL}{g}\right)I$$

where
B is the magnetic flux density between the magnets
L is the length of the copper wire between the magnets.

The student concludes that his readings support the relationship.

Explain why the student's conclusion may not be correct.
Your answer should refer to the readings taken by the student.

(4)

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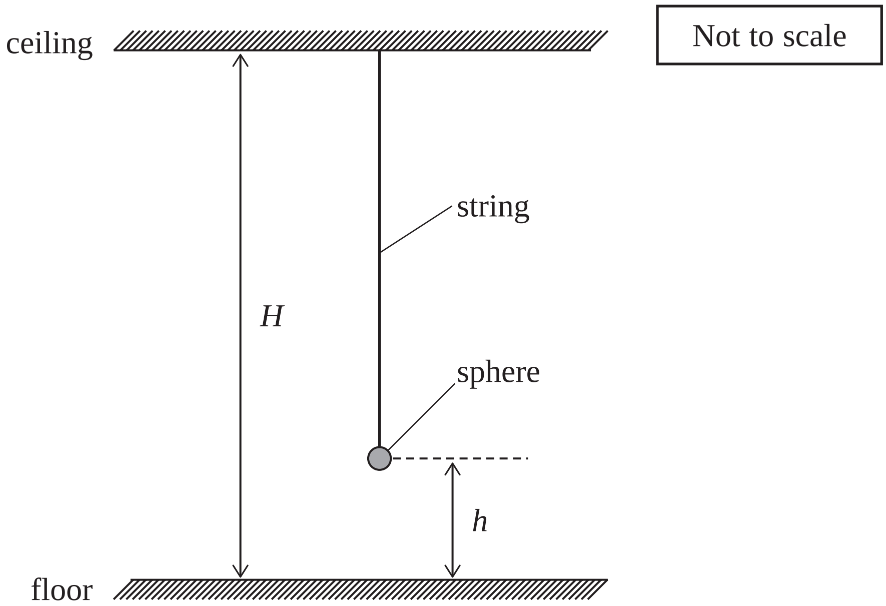
(Total for Question 1 = 8 marks)

2 A student determined the height *H* of a high ceiling using a simple pendulum as shown.



The student displaced the sphere through a small angle, so that it oscillated.
She determined the time period *T* when the centre of the sphere was a distance *h* from the floor.

(a) Show that the relationship between *T* and *h* can be written as

$$T^2 = \frac{4\pi^2 H}{g} - \frac{4\pi^2 h}{g}$$

(2)

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(b) The student used a stopwatch to determine T.

Describe a method, using the pendulum, to obtain a value for H.

Your method should use a suitable graph.

(6)

(c) Explain how a video recording may improve the method.

(2)

(Total for Question 2 = 10 marks)

3 The relationship between air pressure P and height h above sea level is given by

$$P = P_0 e^{-bh}$$

where P_0 is the air pressure at sea level and b is a constant.

(a) Explain why a graph of $\ln P$ against h can be used to determine a value for b.

(2)

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(b) The table shows values of P measured at different values of h.

***h* / m**	***P* / kPa**	
305	97.7	
762	92.5	
1372	85.9	
1829	81.2	
2438	75.3	
3048	69.7	

(i) Plot a graph of $\ln P$ against h on the grid opposite.

Use the additional column for your processed data.

(5)

(ii) Determine the gradient of the graph.

(3)

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Gradient = ...

(iii) The gradient of the graph is given by

$$\text{gradient} = -\frac{Mg}{kT}$$

where
M = mass of one air molecule
k = Boltzmann constant
T = 288 K

Determine a value for M.

(3)

M = ...

(iv) The lowest point on dry land is 414 m below sea level.

Determine the value of P for this point.

(3)

P = ...

(Total for Question 3 = 16 marks)

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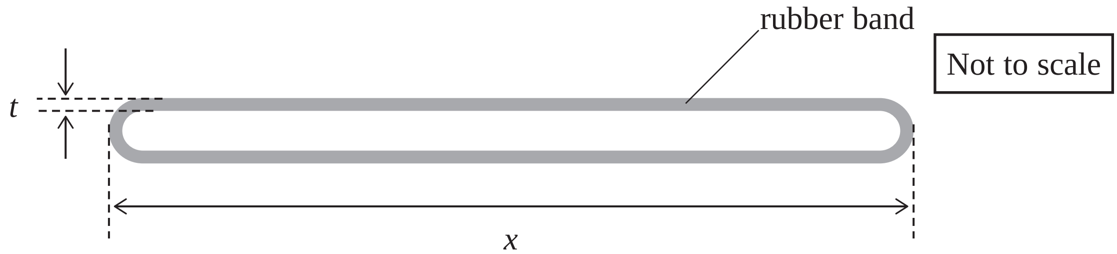
4 A student made measurements on a rubber band as shown.



The rubber band has a rectangular cross-section.

(a) The student used a micrometer screw gauge to measure the thickness *t*.

(i) Explain **one** technique she should use to measure *t*.

(2)

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(ii) The student recorded the following measurements.

***t* / mm**	1.02	1.06	1.05	1.01

Calculate the mean value of *t* in mm.

(1)

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Mean value of *t* = ... mm

(iii) Determine the percentage uncertainty in *t*.

(2)

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Percentage uncertainty in *t* = ...

(iv) Folding the rubber band and measuring the total thickness of four layers would reduce the percentage uncertainty in t.

Explain the effect of folding the rubber band on the percentage uncertainty in t.

(2)

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(v) The student used a metre rule to measure the length x and used the micrometer screw gauge to measure the width w of the rubber band.

She determined the volume of the rubber band using the formula

$$V = 2xwt$$

Suggest **two** reasons why the calculated volume may **not** be accurate.

(2)

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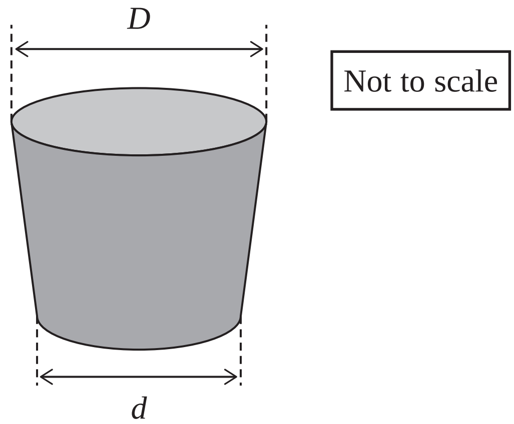
(b) The student made measurements on a rubber bung as shown.



The average cross-sectional area A of the bung is given by

$$A = \frac{\pi}{12}(D^2 + d^2 + Dd)$$

(i) Show that the uncertainty in D^2 is about $0.07\,\text{cm}^2$.

$D = 3.45\,\text{cm} \pm 0.01\,\text{cm}$

(2)

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(ii) Show that the uncertainty in A is about $0.05\,\text{cm}^2$.

$d^2 = 9.36\,\text{cm}^2 \pm 0.06\,\text{cm}^2$
$Dd = 10.56\,\text{cm}^2 \pm 0.07\,\text{cm}^2$

(2)

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(c) The student determined the density of the rubber band and the density of the rubber bung. She also determined the corresponding percentage uncertainty in each value, as shown.

	Rubber band	**Rubber bung**
Density / g cm^{-3}	1.15	1.52
Percentage uncertainty	4.3	1.2

Deduce whether the rubber band and the rubber bung could be made of the same type of rubber.

(3)

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(Total for Question 4 = 16 marks)

TOTAL FOR PAPER = 50 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

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

$$v = u + at$$

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

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

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

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

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Unit 4

Further mechanics

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

Electric and magnetic fields

Electric field	$E = \dfrac{F}{Q}$
Coulomb's law	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \dfrac{V}{d}$
Electrical potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \dfrac{Q}{V}$
Energy stored in capacitor	$W = \dfrac{1}{2}QV$
	$W = \dfrac{1}{2}CV^2$
	$W = \dfrac{1}{2}\dfrac{Q^2}{C}$
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	$\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field	$r = \frac{p}{BQ}$
Mass-energy	$\Delta E = c^2 \Delta m$

Unit 5

Thermodynamics

Heating	$\Delta E = mc\Delta\theta$
	$\Delta E = L\Delta m$
Ideal gas equation	$pV = NkT$
Molecular kinetic theory	$\frac{1}{2}m<c^2> = \frac{3}{2}kT$

Nuclear decay

Mass-energy	$\Delta E = c^2\Delta m$
Radioactive decay	$A = \lambda N$
	$\frac{dN}{dt} = -\lambda N$
	$\lambda = \frac{\ln 2}{t_{1/2}}$
	$N = N_0 e^{-\lambda t}$
	$A = A_0 e^{-\lambda t}$

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

Astrophysics and cosmology

Gravitational field strength	$g = \frac{F}{m}$
Gravitational force	$F = \frac{Gm_1m_2}{r^2}$
Gravitational field	$g = \frac{Gm}{r^2}$
Gravitational potential	$V_{grav} = \frac{-Gm}{r}$
Stefan-Boltzmann law	$L = \sigma AT^4$
Wien's law	$\lambda_{max}T = 2.898 \times 10^{-3}\,\mathrm{m\,K}$
Intensity of radiation	$I = \frac{L}{4\pi d^2}$
Redshift of electromagnetic radiation	$z = \frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$
Cosmological expansion	$v = H_0 d$

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