Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
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Centre Number | Candidate Number

# Pearson Edexcel International Advanced Level

**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.
- **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.



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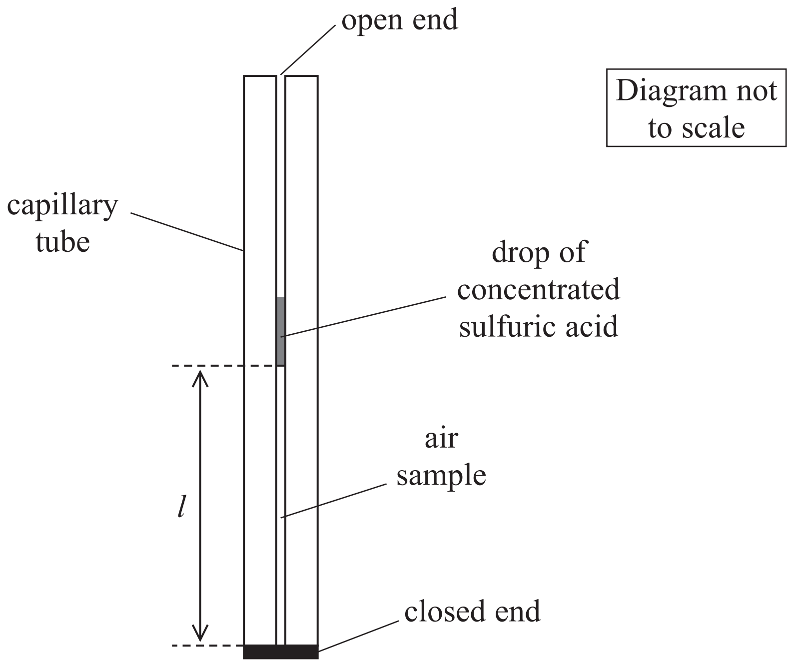
**Answer ALL questions.**

**1** A student investigated the relationship between the length $l$ of a column of air and its temperature $\theta$ using the apparatus shown.




A sample of air is trapped inside the tube between the closed end and the drop of concentrated sulfuric acid.

(a) Suggest why one end of the tube is left open.

**(1)**

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(b) The student suggested placing the apparatus in a beaker of boiling water and allowing the water to cool. Boiling water is a hazard.

Explain one other reason why this method may be hazardous.

**(2)**

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(c) The capillary tube was attached to a 30 cm ruler and placed in a beaker of water at room temperature. The water was heated gradually and $\theta$ was measured using a thermometer.

(i) State two techniques that should be used to ensure the measurement of $\theta$ is as accurate as possible.

**(2)**

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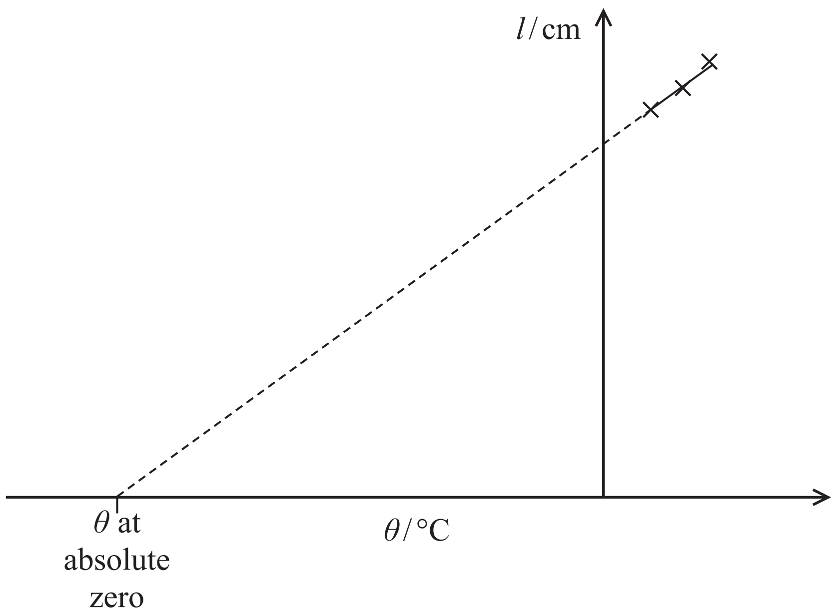
(ii) The student recorded the following measurements.

| **$\theta$ / °C** | **$l$ / cm** |
|---|---|
| 19.0 | 16.0 |
| 35.0 | 16.9 |
| 49.0 | 17.7 |

The student predicted that a graph of $l$ against $\theta$ could be used to estimate a value for $\theta$ at absolute zero as shown.



Discuss whether the student's measurements would lead to an accurate value of $\theta$ at absolute zero.

**(3)**

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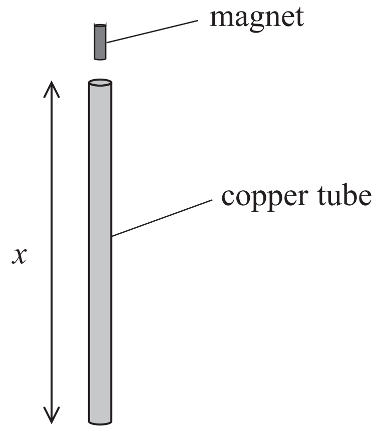
**(Total for Question 1 = 8 marks)**

**2** A student investigated Lenz's law using the apparatus shown.




The student dropped the magnet into the copper tube and measured the time $t$ for the magnet to reach the bottom of the tube.

(a) The student had a large number of copper tubes of different lengths $x$. He predicted that the magnet would fall with constant acceleration $a$ inside the copper tubes.

Devise a plan, using a graphical method, to test this prediction.

**(6)**

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(b) Explain a possible source of error in this investigation.

**(2)**

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**(Total for Question 2 = 8 marks)**

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**3** A radioactive source emits beta radiation and gamma radiation.

(a) State two precautions that should be taken when using this source.

**(2)**

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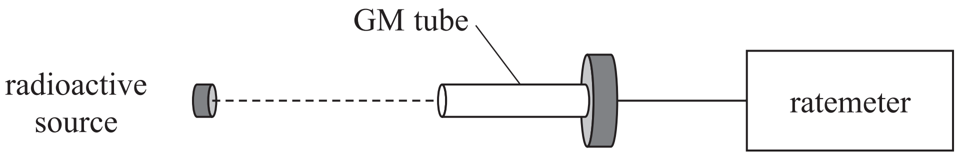
(b) The radiation emitted from a radioactive source can be investigated using the apparatus shown. The Geiger-Muller (GM) tube detects beta radiation and gamma radiation.




The ratemeter displays the count rate from all radiation detected by the GM tube.

Explain why the background count rate should be measured.

**(2)**

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(c) The corrected count rate $C$ varies over time $t$ according to the relationship

$$C = C_0 \, e^{-\lambda t}$$

where $C_0$ is the initial count rate and $\lambda$ is the decay constant.

Explain how a graph of $\ln C$ against $t$ can be used to determine a value for $\lambda$.

**(2)**

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(d) The source contained two radioactive isotopes, X and Y. The table below shows the corrected count rate as the isotopes decayed.

| $t$ / hours | $C$ / $s^{-1}$ | |
|---|---|---|
| 0.00 | 633 | |
| 2.00 | 217 | |
| 4.00 | 167 | |
| 6.00 | 140 | |
| 8.00 | 126 | |
| 10.00 | 107 | |
| 12.00 | 98 | |

(i) Plot a graph of $\ln C$ against $t$ on the grid opposite. Use the additional column in the table to record your processed data.

**(5)**

(ii) Isotope X has a half-life of approximately 30 minutes.

Determine a value of $\lambda$, in $\text{hours}^{-1}$, for isotope Y.

**(3)**

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$\lambda$ = ........................................ $\text{hours}^{-1}$

(iii) Hence determine the half-life $t_{½}$ for isotope Y.

**(2)**

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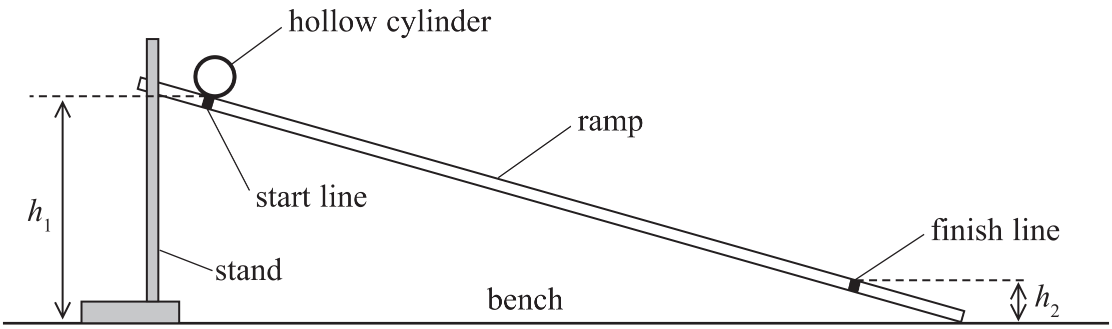
$t_{½}$ = ........................................

**(Total for Question 3 = 16 marks)**

**4** A student used the apparatus shown to investigate the time taken for a hollow cylinder to roll down a ramp.




(a) (i) The student measured the height $h_1$ of the start line from the bench using a metre rule.

State two precautions she should take to ensure the measurement is as accurate as possible.

**(2)**

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(ii) The student measured the height $h_2$ of the finish line. She recorded the difference in height $\Delta h$ between the start line and finish line as 65 mm ± 1 mm.

Explain why the uncertainty in $\Delta h$ is 1 mm.

**(2)**

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(b) The student placed the cylinder on the start line and released it. She immediately started a stopwatch and measured the time $t$ for the cylinder to roll to the finish line. She repeated the measurements several times as shown.

| $t$ / s | 2.10 | 1.86 | 1.94 | 1.89 |
|---|---|---|---|---|

(i) Calculate the mean value of $t$ and its uncertainty.

**(2)**

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Mean value of $t$ = .............................................. ± ..............................................

(ii) The student made the ramp less steep by reducing the value of $h_1$.

Explain how this might improve the measurement of $t$.

**(2)**

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(c) Two students each carried out this procedure for another value of $\Delta h$. They recorded the following times for the same value of $\Delta h$.

| **Student** | ***t* / s** | | | | **Mean *t* / s** |
|---|---|---|---|---|---|
| A | 2.45 | 2.50 | 2.38 | 2.41 | 2.44 |
| B | 2.48 | 2.45 | 2.43 | 2.40 | 2.44 |

Compare the accuracy and precision of the data that each student collected.

**(4)**

(d) The relationship between $t$ and the acceleration of free fall $g$ is given by

$$t^2 = \frac{4s^2}{g\Delta h}$$

where $s$ is the distance along the ramp between the start line and the finish line.

The student recorded the following values.

$t = 2.44\,\text{s} \pm 0.04\,\text{s}$
$s = 80.0\,\text{cm} \pm 0.1\,\text{cm}$
$\Delta h = 43\,\text{mm} \pm 1\,\text{mm}$

(i) Determine a value for $g$.

**(2)**

$g =$ ..............................

(ii) Determine the percentage uncertainty in the value of $g$.

**(2)**

Percentage uncertainty = ..............................

(iii) Deduce whether the value of $g$ is accurate.

**(2)**

**(Total for Question 4 = 18 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 $\rho = \frac{m}{V}$

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

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

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

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

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

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

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

*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 | $A = \lambda N$ |
| | $\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$ |
| | $\lambda = \frac{\ln 2}{t_{1/2}}$ |
| | $N = N_0 \mathrm{e}^{-\lambda t}$ |
| | $A = A_0 \mathrm{e}^{-\lambda t}$ |

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

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