# WORKBOOK

AQA A-LEVEL

# Physics 1

YEAR 1 TOPICS

- Measurements and their errors
- Particles and radiation
- Waves
- Mechanics and materials
- Electricity
- Periodic motion

- ✓ Build confidence with practice questions
- ✓ Practise key maths and practical skills
- ✓ Prepare for assessment with exam-style questions

Jeremy Pollard

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# Physics 1

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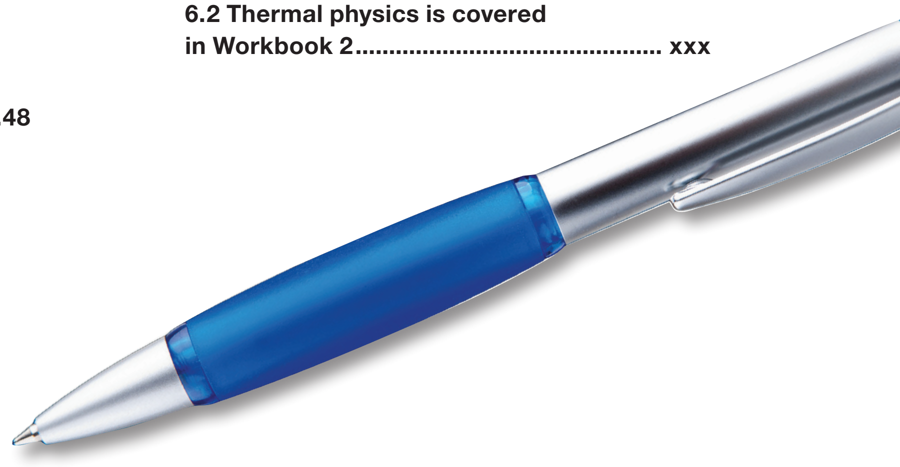

AQ: please check the following carefully and amend if needed

# About this book

1 **This workbook** will help you to prepare for AQA A-level Physics Topics 1–5 and 6.1.

2 **Sections 1–5 and 6.1** could be assessed in:

- A-level Paper 1, which lasts for 2 hours and covers Sections 1–5 and 6.1 (periodic motion). Paper 1 is worth 34% of the A-level. There is a mixture of short- and long-answer questions, worth 60 marks, and 25 multiple-choice questions.
- A-level Paper 2 assumes knowledge from Sections 1–6.1.

3 **For each topic** in this workbook there are:

- stimulus materials, including key terms and concepts
- short-answer questions that build up to exam-style questions
- spaces for you to write or plan your answers
- questions that test your mathematical skills

4 **Answering the questions** will help you to build your skills and meet the assessment objectives AO1 (knowledge and understanding), AO2 (application) and AO3 (analysis).

5 **Worked answers** are included throughout the practice questions to help you understand how to gain the most marks.

6 Icons next to the question will help you to identify:

where the practical elements of the course are covered

where your calculations skills are tested

where questions draw on synoptic knowledge, i.e. content from more than one topic

60 how long this question should take you

7 **You still need** to read your textbook and refer to your revision guides and lesson notes.

8 **Marks available** are indicated for all questions so that you can gauge the level of detail required in your answers.

9 **Timings** are given for the exam-style questions to make your practice as realistic as possible.

10 Answers are available at: **www.hoddereducation.co.uk/workbookanswers.**

# 1.1 Measurements and their errors

## Use of SI units and their prefixes

The seven fundamental base units are: mass (kilogram, kg), length (metre, m), time (second, s), quantity of matter (mole, mol), temperature (kelvin, K), electric current (ampere, A) and light intensity (candela, cd).

| Prefix | T tera | G giga | M mega | k kilo | c centi | m milli | µ micro | n nano | p pico | f femto |
|---|---|---|---|---|---|---|---|---|---|---|
| Standard form | $\times 10^{12}$ | $\times 10^{9}$ | $\times 10^{6}$ | $\times 10^{3}$ | $\times 10^{2}$ | $\times 10^{-3}$ | $\times 10^{-6}$ | $\times 10^{-9}$ | $\times 10^{-12}$ | $\times 10^{-15}$ |

Non-fundamental quantities are derived from the base units, e.g. speed, which is distance divided by time, $m\,s^{-1}$.

Sometimes there are more convenient units, e.g. for energy, which can also be in kilowatt-hours, kWh, or electron-volts, eV.

**Practice questions**

**1** Write the following quantities using standard form and suitable prefixes. (AO1) **3 marks**

**a** atomic radius of a carbon atom, 0.000 000 000 07 m

.......................................................................................................................................

**b** wavelength of a helium–neon laser, 0.000 000 632 8 m

.......................................................................................................................................

**c** mass of the P&O cruise ship *Britannia*, 141 000 000 kg

.......................................................................................................................................

**2** Electrical power, *P*, is calculated using the equation $P = VI$, where $V$ is the potential difference and $A$ is the current. The measured values for a nerve cell are $V = 0.02\,\mu V$ and $I = 0.07\,mA$. The electrical power is: (AO1) **1 mark**

A 14 pW ☐ B 1.4 pW ☐

C 14 nW ☐ D 1.4 nW ☐

**3** The electronvolt is a unit of energy equivalent to $1.6 \times 10^{-19}$ J. The ionisation energy of hydrogen is $2.176 \times 10^{-19}$ J. The ionisation energy of hydrogen in eV is: (AO2) **1 mark**

A 0.74 eV ☐ B 1.36 eV ☐

C 3.8 eV ☐ D 13.6 eV ☐

## Limitation of physical measurements

There are two types of measurement error.

- Systematic errors can happen if a measurement is consistently too large or too small.
- Random errors can happen when repeating a measurement gives an unpredictable and different result.

The quality of a measurement can be assessed in terms of accuracy, precision, repeatability, reproducibility or resolution.

Uncertainty is a measure of the spread of the value which is likely to include the 'true value' and can be expressed as fractional uncertainty and percentage uncertainty.

## Practice questions ?

**4** The frequency, $f$, of a water wave inside a ripple tank is given by the equation:

$$f = \frac{c}{\lambda}$$

where $c$ is the speed of the wave, and $\lambda$ is the wavelength of the wave. The speed of the wave is measured as $2.6\,\text{cm s}^{-1}$ with an absolute uncertainty of $\pm 0.2\,\text{cm s}^{-1}$, and the wavelength of the wave is 0.8 cm with an absolute uncertainty of $\pm 0.1$ cm. Calculate the value of $f$ and determine its percentage error. (AO2) **3 marks**

### Worked example

Step 1: Calculate the percentage error in $c$ and $\lambda$:

$$\text{percentage error in } c = \frac{0.2}{2.6} \times 100 = 7.7\%$$ ✓

$$\text{percentage error in } \lambda = \frac{0.1}{0.8} \times 100 = 12.5\%$$ ✓

Step 2: Calculate the percentage error in $f$ by adding the percentage errors in $c$ and $\lambda$:

$$\text{percentage error in } f = 7.7 + 12.5 = 20.2\%$$ ✓

**5** The fringe spacings measured on a screen as part of a Young's double slit experiment are shown below.

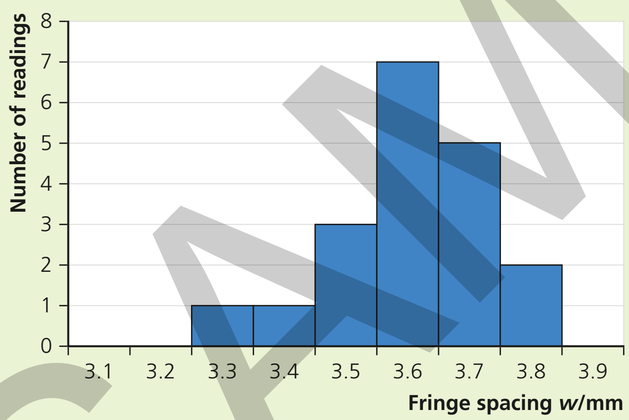


**Figure 1.1** Fringe width distribution

Use the histogram to determine the mean average of the fringe width and use the spread of the data to determine the error on this measurement. (AO2) **3 marks**

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**6** An ammeter has a systematic zero error of –0.03 A. The ammeter is then connected into a circuit and reads a current of 1.74 A. The real reading should be: **1 mark**

A 1.77 A ⬭ B 1.71 A ⬭

C 1.80 A ⬭ D 1.68 A ⬭

**7** A student measures and records the following ten repeat readings of the diameter of a wire in mm using a micrometer.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1.72 | 1.73 | 1.72 | 1.71 | 1.69 | 1.71 | 1.73 | 1.69 | 1.71 | 1.68 |

Calculate:

**a** the mean diameter of the wire **1 mark**

..............................................................................................................................

**b** the range of the readings **1 mark**

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**c** the absolute error of the readings **1 mark**

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**d** the percentage error of the readings **1 mark**

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## Estimation of physical quantities

This can be done by comparing the value that you are estimating to values that you know well, such as your height, mass etc.

A quantity is an '**order of magnitude**' bigger than another quantity, if it is about ten times bigger. Two orders of magnitude difference would be 100 times larger, or $10^2$ etc.

Approximated estimated values are usually given as 'orders of magnitude' to the nearest power of 10.

**Practice questions ?**

**8** Estimate 'order of magnitude' values for the following quantities: (AO2) **5 marks**

**a** the volume of your physics laboratory in $m^3$

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**b** the mass of your pencil case in kg

..............................................................................................................................

**c** your standard walking speed in $m\,s^{-1}$

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**d** the temperature of a Bunsen burner safety flame in °C

..............................................................................................................................

**e** the breaking force of a human hair in N

..............................................................................................................................

**9** Some physical quantities can be measured directly, while others are estimates. Tick one box in the table next to each of the physical quantities. (AO3)

| Physical quantity | Measurable quantity | Estimated quantity |
|---|---|---|
| The velocity of a tennis ball in flight | | |
| The position of an electron within and atom | | |
| The direction of the Earth's magnetic field at your house | | |
| The age of the Universe | | |

**10** The weather forecast for tomorrow is an estimate. The accuracy of the Met Office's 4-day forecast is now as accurate as the 1-day forecast was 30 years ago. Suggest two reasons why the accuracy has improved. (AO3)

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## Exam-style questions

These questions will require knowledge from across the topic to answer.

**1** This question is about an experiment to measure the Earth's gravitational field strength, *g*. 34

A student performs a simple experiment measuring the period of oscillation of a boiling tube, partially filled with lead shot, bobbing up and down inside a beaker of water.

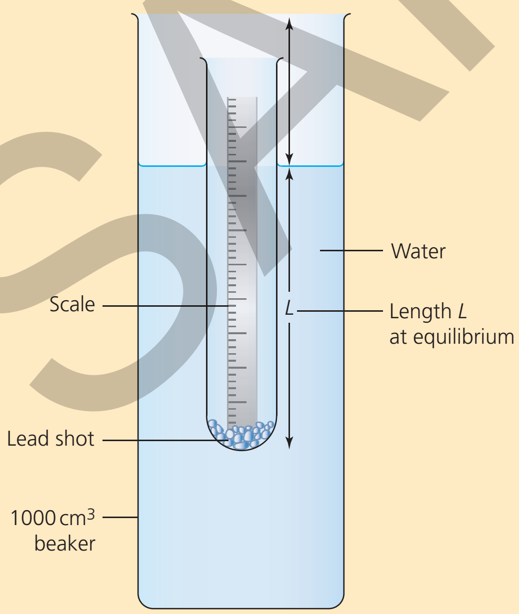


**Figure 1.2 An oscillating boiling tube**

**a** The student suggests that the period of oscillation $T$ is related to $L$ and $g$ by the equation:

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

- The density of lead is given as 11.3 g cm$^{-3}$. The minimum mass of lead that can be used in this experiment fills the bottom of the boiling tube to a depth of about 0.5 cm and the maximum mass of lead that can be used fills the bottom of the boiling tube to a depth of about 2 cm.
- Estimate a range of masses of lead shot for this experiment. **2 marks**

Minimum mass: ...............................

Maximum mass: ..............................

**b** When $L$ = 10.5 cm, the student measures $T$ ten times. Her values are shown below:

0.65 s 0.65 s 0.64 s 0.65 s 0.63 s 0.65 s 0.68 s 0.65 s 0.66 s 0.65 s

**i** Use this data to determine the mean value of $T$. **1 mark**

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Mean value of $T$: ..........................................................................................................

**ii** Use the spread of the data to determine the absolute uncertainty in this measurement. **2 marks**

.........................................................................................................................................

Absolute uncertainty of $T$: ..............................................................................................

**iii** The student estimates the uncertainty of the measurement of $L$ to be $\pm$0.2 cm. Use this data and your value from ii, to determine the percentage uncertainty in the value of $g$. **3 marks**

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Percentage uncertainty of $g$: ...............................

**c i** The student plots a graph of $T^2$ against $L$ as shown in Figure 3. She estimates the uncertainty in $T^2$ to be $\pm$0.05 s$^2$ and uses this value to plot error bars. She also thinks that (0,0) is a significant point on this graph, and that any lines of fit must go through this point on the graph.

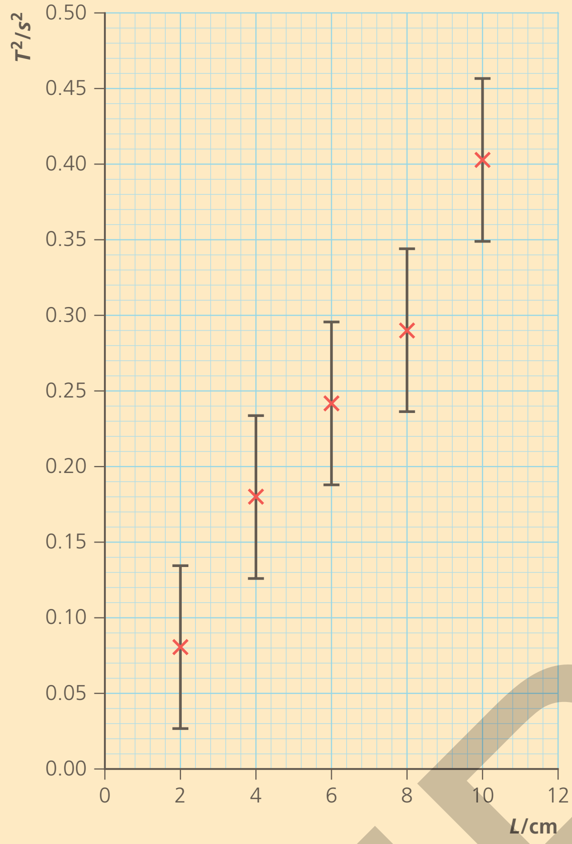


**Figure 1.3**

Determine:

- the maximum gradient $G_{max}$ of a line that passes through the origin and all the error bars
- the minimum gradient $G_{min}$ of a line that passes through the origin and all the error bars **3 marks**

$G_{max}$: ........................................................................................................................

$G_{min}$: ........................................................................................................................

ii Determine $g$ using your values of $G_{max}$ and $G_{min}$. **2 marks**

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$g$ = ........................ m s$^{-2}$

iii Determine the percentage uncertainty in your value of $g$. **3 marks**

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percentage uncertainty in $g$ = ........................ %

iv The student thinks that she has plotted the error bars incorrectly. She suggests that the error bars should be 15% of the *y*-value of the point plotted. Insert a tick (✓) in each row of the table to determine the effect, if any, on the values that you would obtain for $G_{max}$, $G_{min}$ and $g$. **3 marks**

| Value | Decreased | Unaffected | Increased |
|---|---|---|---|
| $G_{max}$ | | | |
| $G_{min}$ | | | |
| $g$ | | | |