1.2 Uncertainties & Errors

Question Paper

Course	DP IB Physics
Section	1. Measurement & Uncertainties
Topic	1.2 Uncertainties & Errors
Difficulty	Easy

Time allowed: 70

Score: /55

Percentage: /100

Question 1a

A student uses a stopwatch to measure the time taken for a pendulum to complete one swing.

The display on the stopwatch after the pendulum completes 10 swings is shown on the diagram.

00:08:40

(a)

For this reading, determine:

(i)

The absolute uncertainty

[1]

(ii)

The fractional uncertainty

[1]

(iii)

The percentage uncertainty

[1]

[3 marks]

Question 1b

(b)

Calculate the mean time for one complete swing with its absolute uncertainty and a percentage uncertainty.

Give your answer to an appropriate number of significant figures.

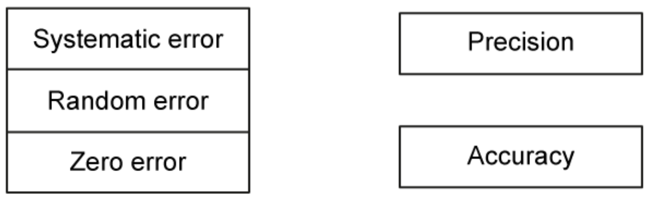
[4]

[4 marks]

Question 1c

(c)

Draw lines between the three types of error to show if the error affects the precision or accuracy of a result.



[2]

[2 marks]

Question 1d

In order to reduce errors, a different student collected measurements of time over 20 cycles instead of 10.

(d)

Complete the following sentences by circling the correct word and placing a tick (✓) next to the correct explanation

Repeated measurements reduce **systematic / random** errors because...

	using a larger sample to calculate the mean value reduces the uncertainty in the final value
	these cause values to be different by the same amount each time, hence they are not influenced by repetition

Repeated measurements have no effect on **systematic / random** errors because...

	using a larger sample to calculate the mean value reduces the uncertainty in the final value
	these cause values to be different by the same amount each time, hence they are not influenced by repetition

[4]

[4 marks]

Question 2a

(a)

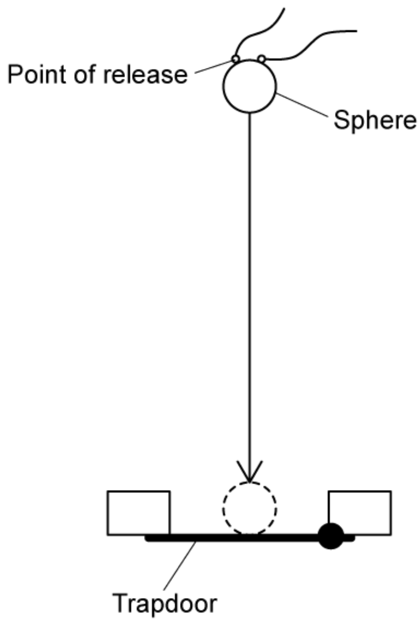
Outline the difference between precise and accurate measurements.

[2]

[2 marks]

Question 2b

A student investigates the relationship between the height that a small metal sphere is dropped from and the time it takes to fall. The ball is dropped from rest through a distance of 543 ± 2 mm.



The student predicts the expected time the sphere should take to fall this distance is 0.323 s, using the following equation:

$$\text{acceleration due to gravity} = \frac{2 \times \textit{distance fallen by centre of mass of sphere}}{(\textit{measured time to fall})^2}$$

The time taken for the sphere to fall from the point of release to a trapdoor is measured. This measurement is repeated a number of times.

Time, t_1 / s	Time, t_2 / s	Time, t_3 / s	Time, t_4 / s	Time, t_5 / s	Time, t_6 / s
0.423	0.422	0.424	0.421	0.423	0.424

(b)
For the student's results:

(i)
Calculate the mean value

[1]

(ii)
Explain why the results are precise but not accurate

[2]

[3 marks]

Question 2c

The student repeats the experiment and obtains the following data:

Measured time to fall	0.322 ± 0.002 s
Distance between the point of release and the trapdoor	543 ± 1 mm
Diameter of the metal sphere	10.0 ± 0.1 mm

(c)
For this data, calculate:

(i)
The total distance fallen by the centre of mass of the sphere

[1]

(ii)
The absolute uncertainty in this distance

[1]

[2 marks]

Question 2d

(d)
Calculate the acceleration due to gravity, including an estimate of the absolute uncertainty in your answer.

You may use the following rules for propagating uncertainties:

Operation	Example	Propagation Rule
Addition & Subtraction	$y = a \pm b$	$\Delta y = \Delta a + \Delta b$ The sum of the absolute uncertainties
Multiplication & Division	$y = a \times b$ or $y = \frac{a}{b}$	$\frac{\Delta y}{y} = \frac{\Delta a}{a} + \frac{\Delta b}{b}$ The sum of the fractional uncertainties
Power	$y = a^{\pm n}$	$\frac{\Delta y}{y} = n\left(\frac{\Delta a}{a}\right)$ The magnitude of n times the fractional uncertainty

[5]

[5 marks]

Question 3a

(a)

List the following currents from largest to smallest percentage uncertainty:

4.1 ± 0.2 A	5 ± 1 mA	7.30 ± 0.23 A	0.5 ± 0.05 mA

[4]

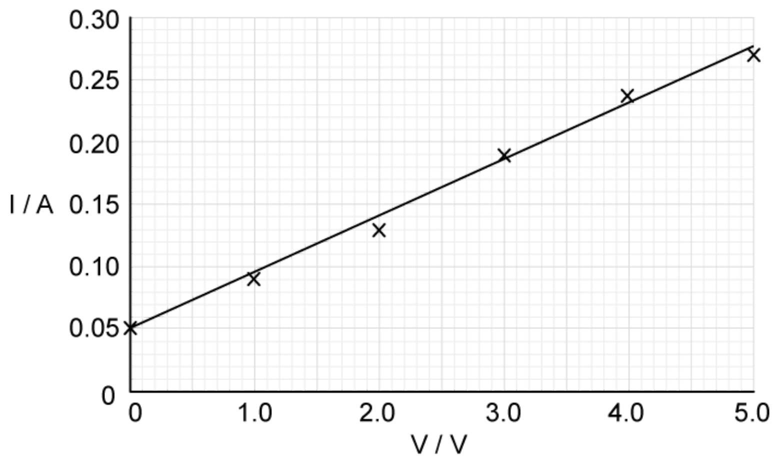
[4 marks]

Question 3b

A circuit is set up to measure the resistance, *R*, of a resistor. The potential difference (p.d), *V*, across the resistor and the current, *I*, are related by the equation:

$$V = IR$$

The readings for the p.d, *V*, and the corresponding current, *I*, are obtained and plotted on a graph with a line of best fit drawn.



(b)

Complete the following sentences by circling the correct words:

Current and potential difference have a **directly / inversely** proportional relationship.

This means when one quantity is zero, the other will be **zero / non-zero.**

On the graph, the y-intercept is **zero / non-zero**, hence, this shows the readings **have / have not** been affected by **systematic / random** uncertainties.

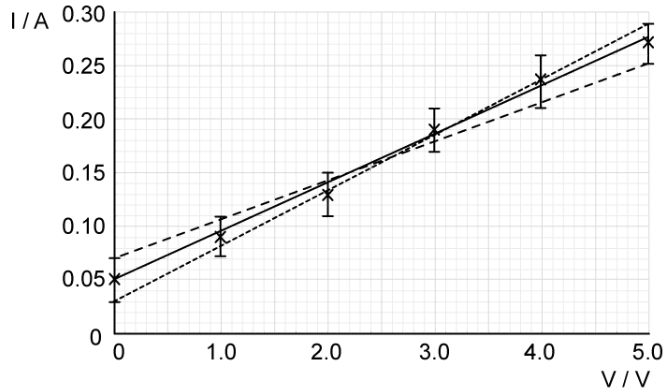
The points on the graph are **close to / scattered around** the line of best fit, hence, this shows the readings **have / have not** been affected by **systematic / random** uncertainties.

[4]

[4 marks]

Question 3c

The student plots error bars on the graph along with lines of maximum and minimum gradient.



Black solid line = best fit line
Dashed black line = maximum fit line
Dotted black line = minimum fit line

(c)

(i)
Determine the percentage uncertainty in the gradient using the following equations of the lines:

Best line	$I = 0.045V + 0.05$
Maximum line	$I = 0.052V + 0.03$
Minimum line	$I = 0.036V + 0.07$

[3]

(ii)
The student suggests the analogue ammeter used to measure the current may have introduced a positive zero error. State what is meant by a zero error.

[1]

(iii)
Outline **one** way a zero error could affect the results and suggest how this type of error can be fixed.

[2]

[6 marks]

Question 3d

In another student's experiment, the resistance of the resistor, *R*, is determined using the following data:

Current, *I*	0.74 ± 0.01 A
Potential difference, *V*	6.5 ± 0.2 V

(d)
Calculate the value of *R*, together with its percentage uncertainty. Give your answer to an appropriate number of significant figures.

[5]

[5 marks]

Question 4a

A vernier calliper has a positive zero error of 0.10 mm.

A student uses the vernier calliper to measure the length of a wire under various loads and records the data in a table.

Load / N	Length / mm	Corrected Length / mm
1.00	3.00	
1.50	3.54	
2.00	4.02	
2.50	4.61	
3.00	4.99	

(a)
Correct the readings of the length of wire in mm for each load.

[2]

[2 marks]

Question 4b

The student wants to determine the extension of the wire after each load is applied. Part of the results table is shown below.

Load / N	Length / mm
1.00	3.00
1.50	3.54

The vernier calliper scales have an uncertainty of ± 0.01 mm

(b)
Using the data, calculate the extension of the wire and its absolute uncertainty.

[2]

[2 marks]

Question 4c

Another student decides to use a ruler to measure the length of the wire for each load and records the data in a table.

Load / N	Length / mm
1.00	3.00
1.50	4.00
2.00	4.00
2.50	5.00
3.00	5.00

The ruler has an uncertainty of ± 1.00 mm.

(c)
Calculate the fractional uncertainty in the length of the wire using a ruler when a load of 2.50 N is applied. Quote the final value with its fractional uncertainty.

[3]

[3 marks]

Question 4d

The student using the vernier calliper to measure the length of the wire obtained a length of 4.61 ± 0.01 mm when a load of 2.50 N was applied.

They quoted the percentage uncertainty in this length as 0.22 %.

(d)
State and explain whether or not the student has:

(i)
Calculated the percentage uncertainty correctly

[2]

(ii)
Quoted the percentage uncertainty correctly

[2]

[4 marks]