1.2 Uncertainties & Errors

Question Paper

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

Time allowed: **60**

Score: **/42**

Percentage: **/100**

Question 1a

One method to determine the acceleration of free fall *g* involves measuring the time period of a simple pendulum *T*. It is related to the length of the pendulum *l* by the equation

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

In this method, *l* was found to be (0.500 ± 0.001) m while the period *T* was measured to be (1.42 ± 0.02) s.

(a)
Based on these measurements, determine the value of *g* and its absolute uncertainty. Give your final answer to an appropriate degree of precision.

[4]

[4 marks]

Question 1b

Another method to determine the acceleration of free fall involves timing the descent of a small metal ball bearing, released vertically via an electromagnetic trapdoor. In one particular trial, the displacement of the ball bearing *s* is measured as (266 ± 1) cm and the time measured *t* is (0.740 ± 0.005) s.

(b)
Determine the value of *g* using this method, and its absolute uncertainty. Give your final answer to an appropriate degree of precision.

[4]

[4 marks]

Question 2a

The length *l* of a simple pendulum is increased by 6%.

(a)
Determine the fractional increase in the pendulum's period, *T*.

You may use the relationship between period *T* and length *l* as:

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

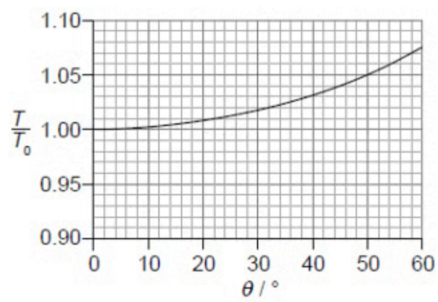
where *g* is the acceleration of free fall.

[3]

[3 marks]

Question 2b

The time period *T* of a pendulum is also related to the amplitude of oscillations θ. Measurements are taken and a graph is obtained showing the variation of $\frac{T}{T_0}$ with angular amplitude θ, where T_0 is the period for small amplitude oscillations:



(b)
Use the information from the graph to

(i)
Deduce the condition for the time period *T* to be considered independent of angular amplitude θ.

[2]

(ii)
Determine the maximum value of θ for which *T* is independent of θ.

[2]

[4 marks]

Question 2c

Typically, using a simple pendulum to determine the acceleration of free fall *g* involves measuring the periodic time *T* and the pendulum length *l*.

(c)
State and explain which piece of measuring equipment is likely to have the biggest impact on the accuracy of the value determined for *g*.

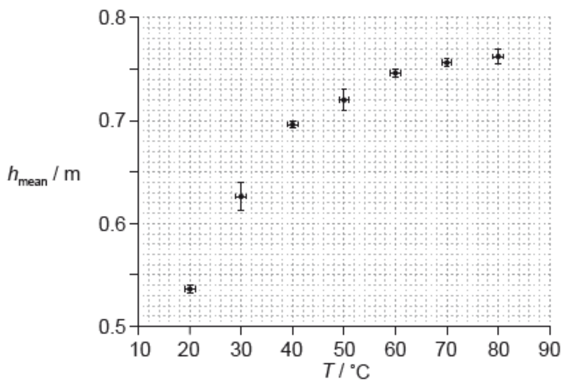
[2]

[2 marks]

Question 3a

An experiment is designed to explore the relationship between the temperature of a ball *T* and the maximum height to which it bounces *h*.

The ball is submerged in a beaker of water until thermal equilibrium is reached. The ball is then dropped from a constant height and the height of the first bounce is measured. This is repeated for different temperatures. The results are shown in the graph, which shows the variation of the mean maximum height h_{mean} with temperature *T*:



(a)
Compare and contrast the uncertainties in the values of h_{mean} and *T*.

[3]

[3 marks]

Question 3b

The experimenter hypothesises, from their results, that h_{mean} is proportional to T^2.

(b)
Suggest how the experimenter could use two points from the graph to validate this hypothesis.

[2]

[2 marks]

Question 3c

(c)
State and explain whether two points from the graph can confirm the experimenter's hypothesis.

[3]

[3 marks]

Question 4a

It is known that the energy per unit time P radiated by an object with surface area A at absolute temperature T is given by:

$$P = e\sigma AT^4$$

where e is the emissivity of the object and σ is the Stefan-Boltzmann constant.

In an experiment to determine the emissivity e of a circular surface of diameter d, the following measurements are taken:

- $P = (3.0 \pm 0.2)$ W
- $d = (6.0 \pm 0.1)$ cm
- $T = (500 \pm 1)$ K

(a)
Determine the value of the emissivity e of the surface and its uncertainty. Give your answer to an appropriate degree of precision.

[4]

[4 marks]

Question 4b

The power dissipated in a resistor can be investigated using a simple electrical circuit. The current in a fixed resistor, marked as 47 kΩ ± 5%, is measured to be (2.3 ± 0.1) A.

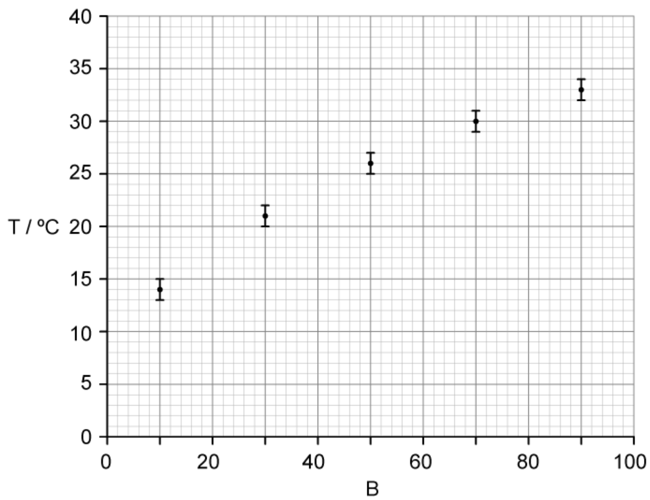
(b)
Determine the power dissipated in this resistor with its associated uncertainty. Give your answer to an appropriate degree of precision.

[3]

[3 marks]

Question 5a

A student investigates the relationship between two variables *T* and *B*. Their results are plotted in the graph shown:



(a)

Comment on the absolute and fractional uncertainty for a pair of data points.

[3]

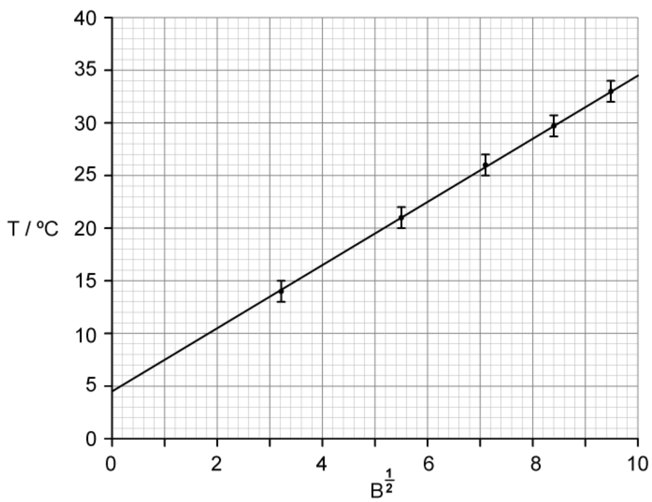
[3 marks]

Question 5b

The student suggests that the relationship between *T* and *B* is of the form:

$$T = a\sqrt{B} + c$$

where *a* and c are constants. To test this suggested relationship, the following graph is drawn:



(b)

Describe a method that would determine the value of c and its uncertainty.

[4]

[4 marks]

Question 5c

(c)

Comment on the student's suggestion from part (b).

[3]

[3 marks]