Experimental technique

Question Paper

Level	International A Level
Subject	Physics
Exam Board	Edexcel
Topic	Lab Skills 2
Sub Topic	Experimental technique
Booklet	Question Paper

Time Allowed: **82 minutes**

Score: **/68**

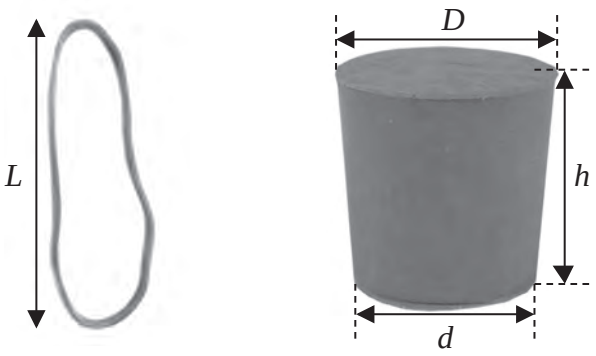
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

Answer ALL questions in the spaces provided.

1 A student investigates the properties of a rubber band and a rubber bung to determine whether they are made from the same type of rubber.



Rubber band Rubber bung

(a) The volume V_1 of the band is given by

$$V_1 = 2Lwt$$

where w is the width of the band and t is the thickness and L is the length shown in the diagram.

(i) The student uses a metre rule to measure L which is approximately 10 cm. Explain why a metre rule is suitable for this measurement.

(2)

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(ii) She uses a micrometer screw gauge to measure w and t and records the following readings with negligible uncertainties.

***L*/cm**	***w*/mm**	***t*/mm**
10.0	9.33	1.03

Use these measurements to calculate V_1 in cm^3.

(2)

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V_1 = ... cm^3

(b) The volume V_2 of the bung is given by

$$V_2 = \frac{\pi h}{12}\left(D^2 + d^2 + Dd\right)$$

where D, d and h are the dimensions shown on the diagram.
The student uses callipers to take measurements of the bung.

(i) Describe how h should be measured.

(2)

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(ii) She records values for the diameters with negligible uncertainty.

$D = 3.45\,\text{cm}$ $d = 3.06\,\text{cm}$

She records the following values for h

h/cm	3.51	3.49	3.53

Use these measurements to calculate V_2 in cm^3.

(2)

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$V_2 =$ ..... cm^3

(iii) Estimate the percentage uncertainty in V_2.

(1)

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Percentage uncertainty = ...

(c) The student uses a top pan balance to record the following readings with negligible uncertainty.

mass of band = 2.23 g mass of bung = 44.48 g

Calculate the densities of the band and the bung.

(3)

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Density of band = ...

Density of bung = ...

(d) The percentage uncertainty in the density of the band is 4%.

Use this value and your results to comment on the suggestion that both the band and the bung are made from the same type of rubber.

(2)

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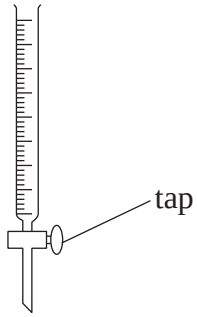
(Total for Question 1 = 14 marks)

2 A burette is a transparent tube that can contain a liquid. It has a tap at the bottom to allow the liquid to flow out. The volume V of liquid remaining in the burette is measured using a scale on the side of the tube.



It is suggested that V decreases exponentially with time as shown by the equation

$$V = V_0 e^{-\frac{t}{b}}$$

where V_0 is the initial volume, t is the time since the tap was opened and b is a constant.

(a) Write a plan for an experiment to determine a value for b using a graphical method and a burette where $V_0 = 100$ cm^3.

Your plan should include

(i) a description of how you would measure V and t and **two** precautions you would take to make your readings as accurate as possible,

(4)

(ii) one source of uncertainty in the measurements,

(1)

(iii) the graph you would plot and how you would use the graph to determine b.

(2)

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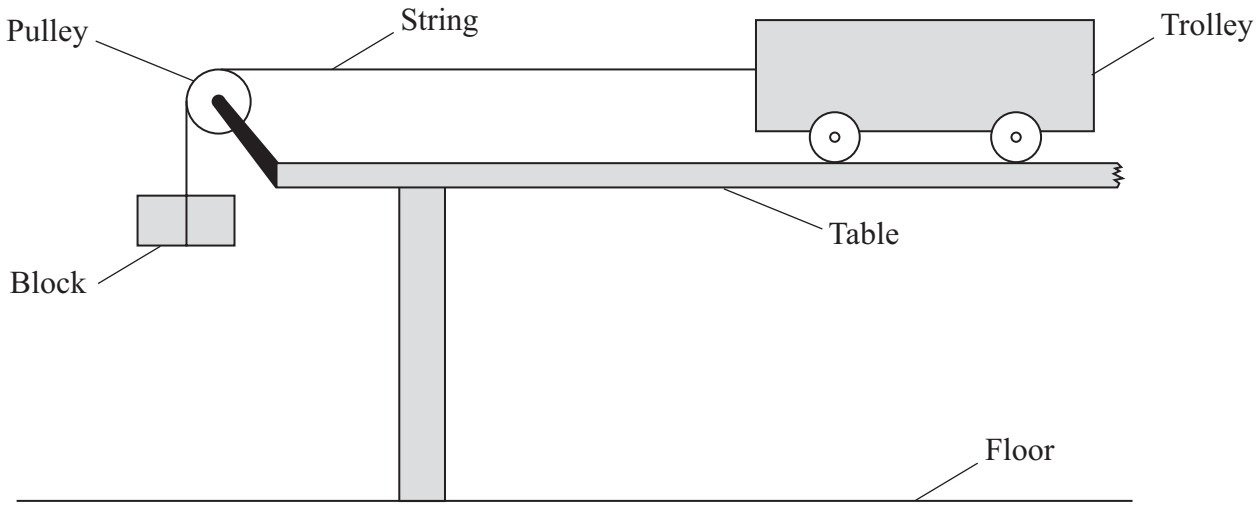
(b) The temperature of the liquid in the burette is increased. This reduces the viscosity of the liquid.

Explain the effect of this on the value of *b* in the equation.

(2)

(Total for Question 2 = 9 marks)

3 A student is asked to carry out an experiment about the energy transferred when a trolley is pulled across a table. The apparatus is set up as shown.



As the block falls it loses gravitational potential energy and the trolley and block together gain kinetic energy. The student is asked to find out what fraction of the gravitational potential energy becomes kinetic energy.

The student writes an outline plan for an experiment and produces a table.

1. *Measure the mass M of the trolley and the mass m of the falling block and set up the apparatus as shown.*
2. *Pull back the trolley so that the block is close to the pulley and release the trolley.*
3. *Measure the distance d fallen by the block.*
4. *Measure the time t it takes to fall.*
5. *The final velocity is given by* $v = \frac{2d}{t}$.
6. *Calculate the gravitational potential energy lost and the kinetic energy gained.*
7. *Divide the kinetic energy by the gravitational potential energy. This is the fraction required.*

Quantity to be measured	*Measuring instrument*	*Precision of measuring instrument*
Masses, M and m		*At least 0.1 g*
Distance, d	*Metre rule*	
Time, t	*Stopwatch*	

Add more detail to improve this plan. You should do the following:

(a) complete the table,

(3)

(b) add a line to the diagram to show the distance d,

(1)

(c) describe how you would measure d accurately (you may add more to the diagram if you wish),

(2)

(d) describe how you would make each measurement of t accurate,

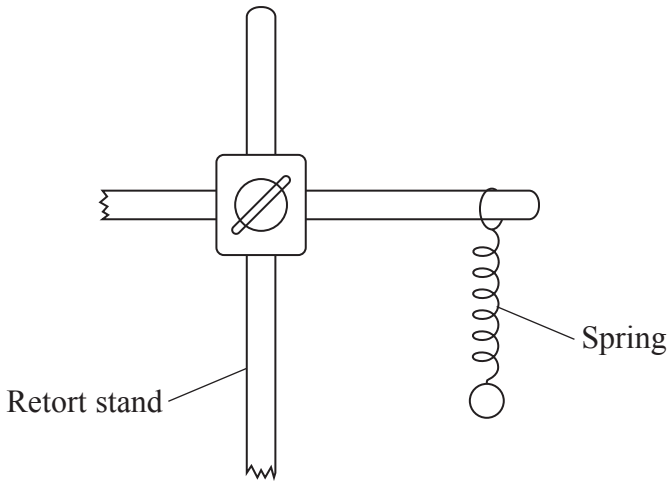
(1)

(e) comment on any safety aspect of this experiment.

(1)

(Total for Question 3 = 8 marks)

4 A student is asked to determine the spring constant for a small spring.



He has the following additional apparatus:

50 g mass hanger with 9 × 50 g masses

stopwatch with a precision of 0.01 s

optical pin.

He is told that the time period T for vertical oscillations of a mass m is

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

where k is the spring constant.

The student decides to determine the period of oscillation for different values of mass.

(a) (i) Describe how he could make his readings for the time period as accurate as possible.

(2)

(ii) Describe the graph he should plot to obtain a straight line and how to determine the spring constant from the graph.

(3)

(b) His teacher suggests using a position sensor with a datalogger instead of the stopwatch.

(i) Draw a diagram to show how this apparatus could be used to record the position of the hanging mass.

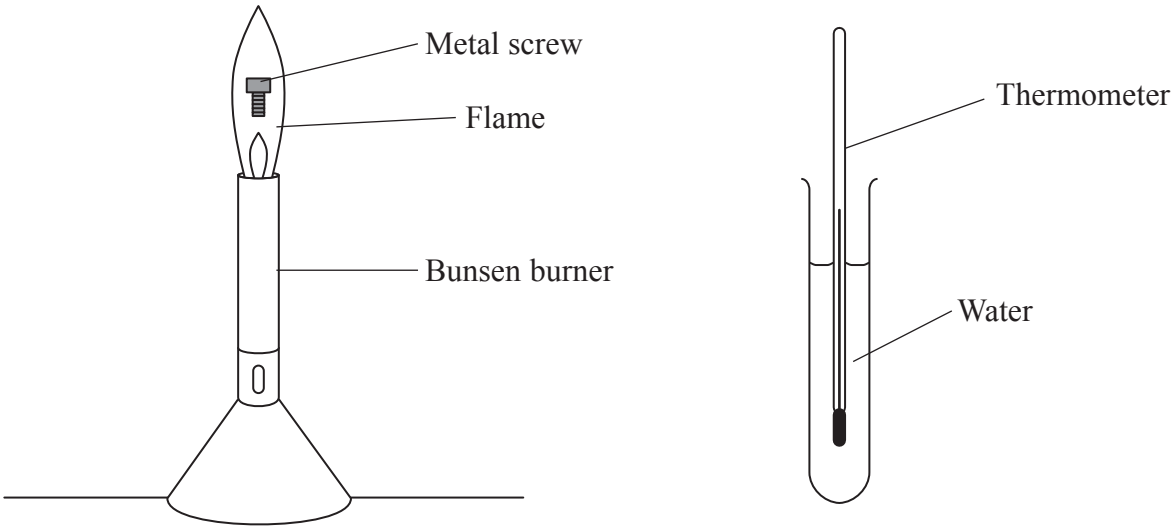
(2)

(ii) Explain how using a position sensor with a datalogger will improve the measurement of the time period.

(2)

(Total for Question 4 = 9 marks)

5 One method to find the temperature of a Bunsen burner flame involves heating a metal screw. The screw is held in the flame and then cooled in a test tube of water.



The thermal energy lost by the screw raises the temperature of the water so that

energy lost by screw in cooling down = energy gained by water in heating up

For both the screw and the water, energy transferred ΔE is given by

$$\Delta E = mc\Delta\theta$$

where m is the mass, c is the specific heat capacity and $\Delta\theta$ is the change in temperature of either the screw or the water. The values of c can be found on the internet.

For the method described above:

(a) state the measurements to be made,

(2)

(b) state **one** technique to improve accuracy,

(1)

(c) give **two** sources of error in your experiment,

(2)

(d) explain which measurement is likely to give the greatest percentage uncertainty,

(2)

(e) comment on safety.

(1)

(Total for Question 5 = 8 marks)

6 A box containing a radioactive source has the following labels.

- Beta emitter only
- Range in air 25 cm

You are to plan an experiment to check that these labels are correct.

Your plan should include:

(a) the apparatus to be used,

(1)

(b) the measurements to be taken,

(3)

(c) a technique to reduce the uncertainty in the measurements,

(1)

(d) how these measurements should be used to check that the labels are correct,

(3)

(e) a comment on safety.

(1)

(Total for Question 6 = 9 marks)

7 A student was asked to determine the density of the metal from which a food can is made.

(a) She calculated the volume of the metal by determining the external volume of the can and subtracting the internal volume.

(i) She measured the external height of the can using a metre rule.

State the precision of a metre rule.

(1)

(ii) She used two set squares and a metre rule to measure the external diameter of the can.

Describe how you would use this apparatus to measure accurately the diameter of a can. Your description should include a diagram.

(2)

(b) The student recorded the following results.

Quantity	Measurements	Mean value
Internal volume / cm^3	391 39	396
Height / cm	10.1 1	10.1
External diameter / cm	7.2 7	7.2
Mass / kg	4.982×10^{-2}	

The volume of a cylinder is given by $V = \pi r^2 h$

where r is the radius of the cylinder and h is its height.

(i) Use these measurements to show that the external volume is about 400 cm^3.

(1)

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.....

(ii) Hence calculate a value for the volume of the metal.

(1)

.....

Volume of metal = ...

(iii) Hence calculate a value for the density of the metal.

(2)

.....

.....

Density of metal = ...

(c) (i) Use the measurements to estimate the percentage uncertainty in the external volume. You should assume the uncertainty in the height measurement is negligible.

(2)

Percentage uncertainty = ... %

(ii) Use the measurements to estimate the percentage uncertainty in the internal volume.

(1)

Percentage uncertainty = ... %

(iii) The volume of metal was determined by subtracting the internal volume of the can from the external volume. This produces a percentage uncertainty for the volume of metal which is greater than 10%.

Suggest why.

(1)

(Total for Question 7 = 11 marks)