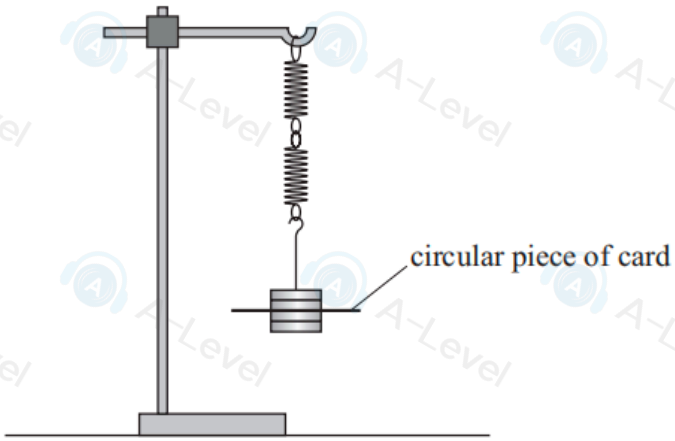
(b) The student modified the apparatus to investigate damped oscillations of the mass-spring system.

She placed a circular piece of card between the masses to act as a damper, as shown.



The amplitude A of the damped oscillations varies with the number n of oscillations as

$$A = A_0 e^{-\lambda n}$$

where A_0 is the initial amplitude and λ is a constant.

Devise a method to determine the time taken for A to decrease to half its initial value.

Your method should include the use of a suitable graph.

(6)

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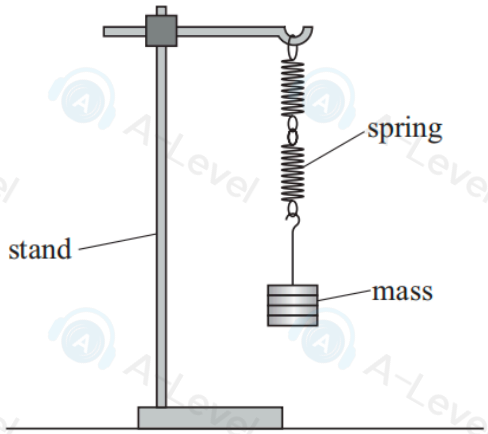
(iii) The student measured the time for multiple oscillations and calculated the mean.

Describe three other techniques she should use to obtain an accurate value for T.

(3)

.....

2 A student investigated the free oscillations of a mass-spring system using the apparatus shown.



The student displaced the mass downwards and allowed the mass to oscillate.

She used a stopwatch to determine the time taken for the mass to complete 5 oscillations.

(a) The student recorded the following measurements.

5*T* / s	7.69	7.58	7.43	7.51

(i) Determine the mean value of the period T.

(2)

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.....

Mean value of T = ...

(ii) Determine the percentage uncertainty in the mean value of T.

(2)

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(c) Describe how the student could investigate how f varies with the volume flow rate of the water.

(3)

(d) The student disconnected the water tank and oscilloscope from the water flow device.

The student placed the water flow device in a river to monitor the flow of the river water overnight.

He connected the coil of the water flow device to a data logger. The data logger recorded the frequency of the pulses.

Give **two** reasons why a data logger is an appropriate piece of equipment to use for this task.

(2)

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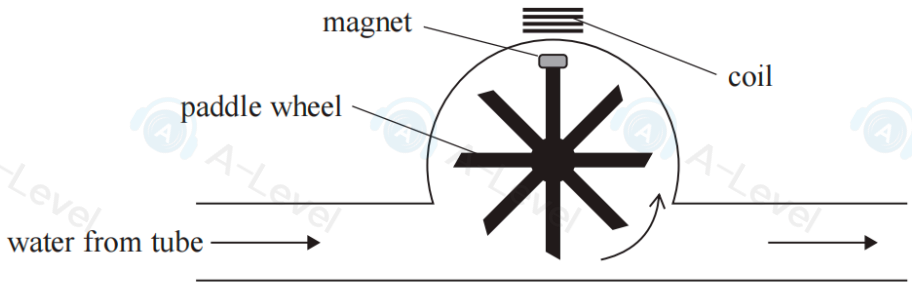
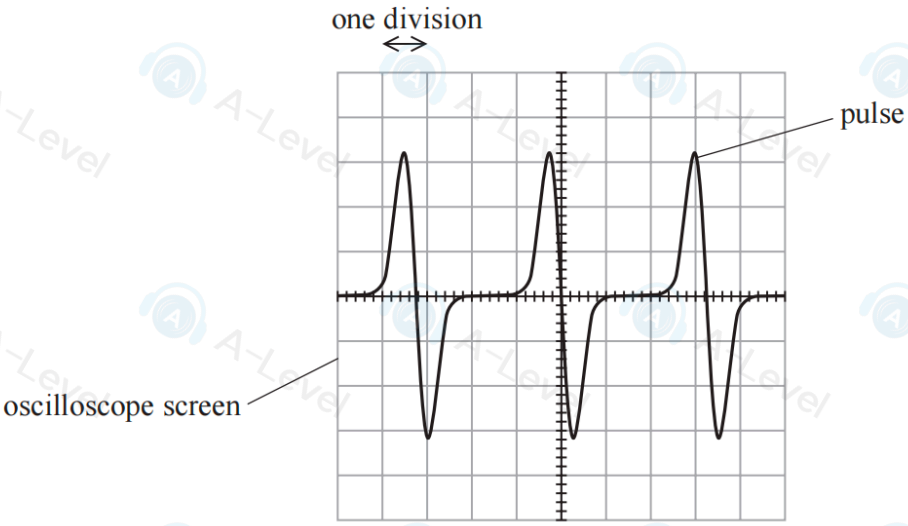
(b) A student connected the tube to the water flow device shown below. A magnet is attached to the paddle wheel.



As water flowed through the device the paddle wheel rotated, making the magnet move past the coil.

The student connected the coil to an oscilloscope.

A series of pulses was displayed on the oscilloscope screen as shown.



The horizontal axis represents time.

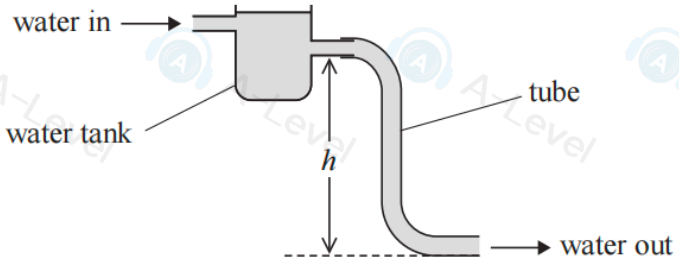
The time scale was set to 50 ms per division.

Calculate the frequency f of the pulses.

(3)

1 A water tank is shown below. The depth of water in the water tank is kept constant.

The height h can be adjusted to vary the volume flow rate of the water moving out of the tube.



(a) Describe a simple method to determine the volume flow rate of the water moving out of the tube.

(3)

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.....

.....

(c) The refractive index of the material used to make the lens is determined using the formula

$$n = 1 + \frac{d^2}{8tf}$$

$d = 5.02\,\text{cm} \pm 0.02\,\text{cm}$
$t = 4.28\,\text{mm} \pm 0.01\,\text{mm}$
$f = 11.6\,\text{cm} \pm 0.2\,\text{cm}$

(i) Determine the value of n.

(2)

.....

.....

.....

.....

$n =$ .....

(ii) Determine the percentage uncertainty in n.

(2)

.....

.....

.....

.....

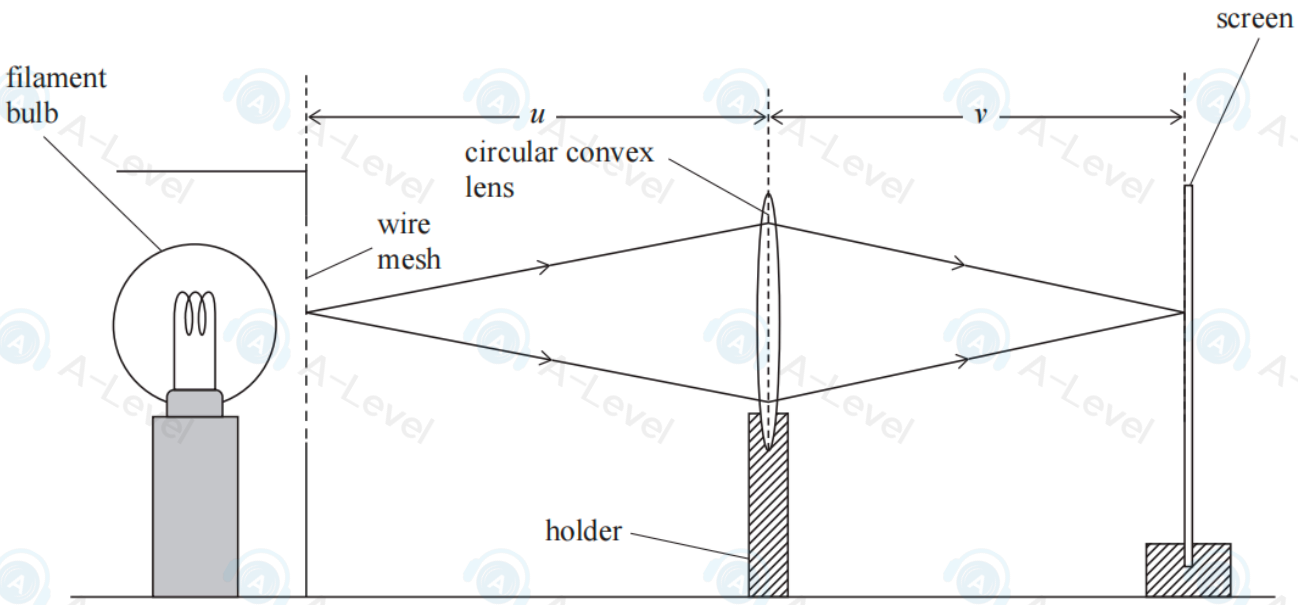
Percentage uncertainty in $n =$ .....

(iii) The refractive index of crown glass is 1.52

Deduce whether the lens could be made of crown glass.

(2)

(b) The student placed the circular convex lens in a holder. She set up the apparatus, as shown.



The student moved the position of the holder until the lens formed a sharp image of the wire mesh on the screen. She measured the distances u and v with a metre rule.

The student determined the focal length f of the lens using the formula

$$f = \frac{uv}{u + v}$$

Show that the uncertainty in f is about 0.2 cm.

$u = 29.6\,\text{cm} \pm 0.1\,\text{cm}$
$v = 19.2\,\text{cm} \pm 0.1\,\text{cm}$
$f = 11.6\,\text{cm}$

(4)

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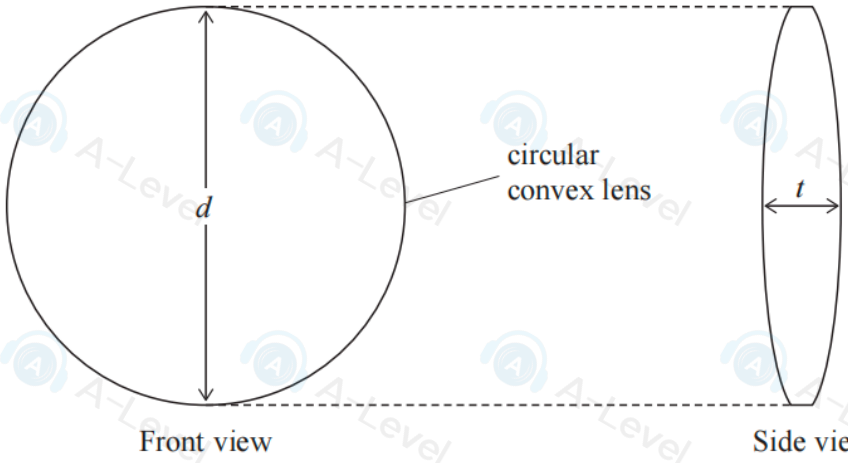
4 A student made measurements of a circular convex lens, as shown.



(a) (i) The student used vernier calipers to measure the diameter *d*.

Explain **one** technique she should use to measure *d*.

(2)

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.....

(ii) The student estimated that the thickness *t* of the centre of the lens was approximately 5 mm.

Explain the most appropriate instrument the student should use for a single measurement of *t*.

Your answer should include a calculation.

(2)

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(c) The student determined the density of the rubber band and the density of the rubber bung. She also determined the corresponding percentage uncertainty in each value, as shown.

	Rubber band	**Rubber bung**
Density / g cm^{-3}	1.15	1.52
Percentage uncertainty	4.3	1.2

Deduce whether the rubber band and the rubber bung could be made of the same type of rubber.

(3)

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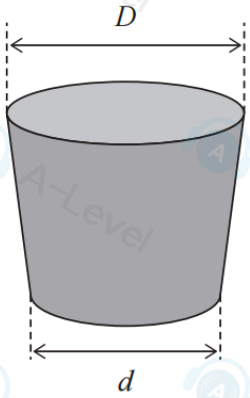
(b) The student made measurements on a rubber bung as shown.



Not to scale

The average cross-sectional area A of the bung is given by

$$A = \frac{\pi}{12}(D^2 + d^2 + Dd)$$

(i) Show that the uncertainty in D^2 is about $0.07\,\text{cm}^2$.

$D = 3.45\,\text{cm} \pm 0.01\,\text{cm}$

(2)

(ii) Show that the uncertainty in A is about $0.05\,\text{cm}^2$.

$d^2 = 9.36\,\text{cm}^2 \pm 0.06\,\text{cm}^2$
$Dd = 10.56\,\text{cm}^2 \pm 0.07\,\text{cm}^2$

(2)

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(iv) Folding the rubber band and measuring the total thickness of four layers would reduce the percentage uncertainty in t.

Explain the effect of folding the rubber band on the percentage uncertainty in t.

(2)

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(v) The student used a metre rule to measure the length x and used the micrometer screw gauge to measure the width w of the rubber band.

She determined the volume of the rubber band using the formula

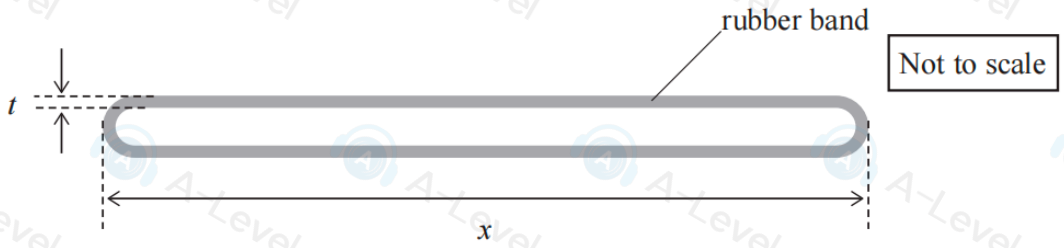
$$V = 2xwt$$

Suggest **two** reasons why the calculated volume may **not** be accurate.

(2)

.....

4 A student made measurements on a rubber band as shown.



The rubber band has a rectangular cross-section.

(a) The student used a micrometer screw gauge to measure the thickness *t*.

(i) Explain **one** technique she should use to measure *t*.

(2)

.....

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.....

.....

(ii) The student recorded the following measurements.

***t* / mm**	1.02	1.06	1.05	1.01

Calculate the mean value of *t* in mm.

(1)

.....

.....

Mean value of *t* = ... mm

(iii) Determine the percentage uncertainty in *t*.

(2)

.....

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(b) The student suggested that the relationship between the temperature θ of the water and time t is

$$\theta = \theta_0 e^{-bt}$$

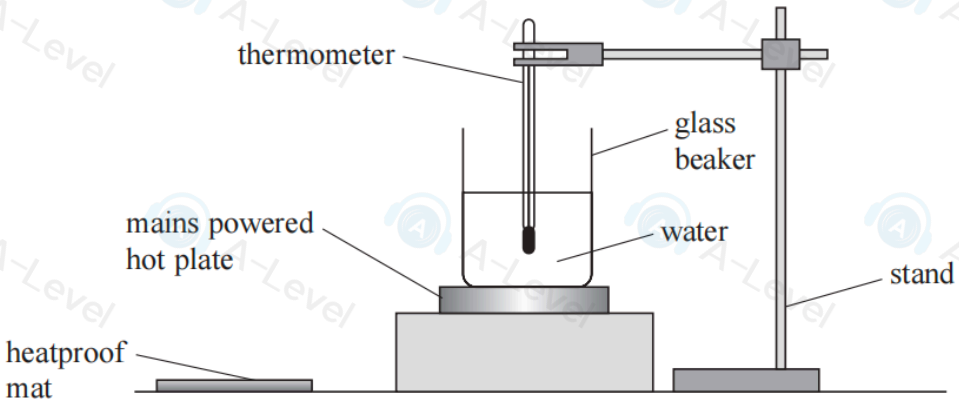
where θ_0 is the initial temperature of the water and b is a constant.

Devise a method to investigate the validity of this relationship.

Your method should use a suitable graph.

(6)

2 A student investigated the cooling of hot water using the apparatus shown.



(a) The student used the hot plate to heat the water until it boiled.

He moved the glass beaker onto the heatproof mat to allow the water to cool.

Identify **one** safety issue and how it may be dealt with.

(2)

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