10 A spring is made from loops of thick steel wire as shown.

There are two extra loops, one on each end of the spring.

(a) A student determined the length of steel used to make the spring by using vernier calipers to measure the width w of the spring.
The length of wire l on each loop is given by $l = \pi w$

The student obtained the following values for w.

***w* / mm**	15.3	15.2	15.4	15.3

(i) Calculate l.

(3)

$l =$ .....

(ii) Estimate the percentage uncertainty in your value for l.

(2)

% uncertainty in $l =$ .....

(iii) Calculate the total length L of wire used to make the spring.

(2)

$L =$ .....

(b) The student measured the diameter d of the steel wire and obtained a value of 2.52 mm.

(i) Explain which instrument he used to measure the diameter.

(2)

(ii) Estimate the percentage uncertainty in the student's value for d.

(1)

% uncertainty in $d =$ .....

(iii) The student used a balance to measure the mass m of the spring.
He obtained a value of 32.0 ± 0.5 g.

Estimate the percentage uncertainty in the mass of the spring.

(1)

% uncertainty in $m =$ .....

(iv) The student calculated the density ρ of the steel using the equation

$$\rho = \frac{m}{V}$$

Calculate the percentage uncertainty in his value for the density of steel.

(1)

% uncertainty in value for density of steel = ...

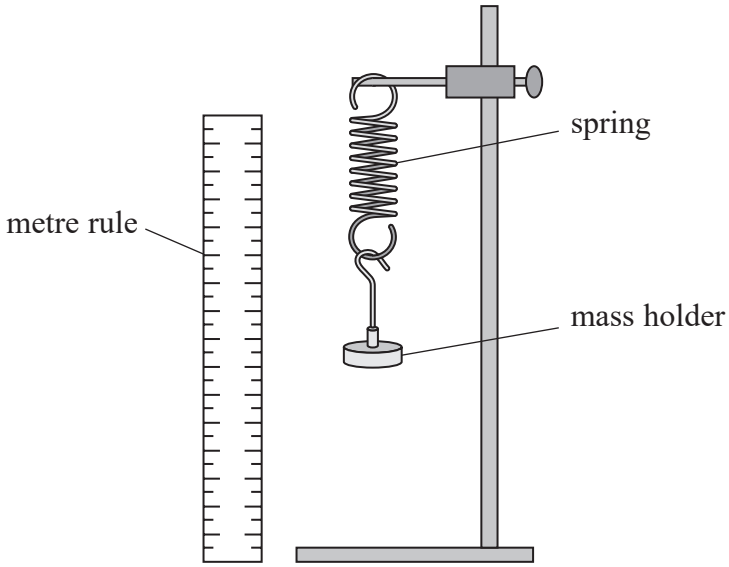
(v) Determine whether the data collected leads to a value for the density of steel in agreement with the standard value.

density of steel = 7 800 kg m^{-3}

(4)

(Total for Question 10 = 16 marks)

10 A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached as shown.



(a) The student measured the length of the spring as he added masses to the holder. The rule was held as shown to measure the distance between the top and bottom coils of the spring. He determined the extension for each value of total mass on the holder. He did this by subtracting the original length of the spring from each extended length.

(i) Explain whether this method would produce accurate values for the extensions of the spring.

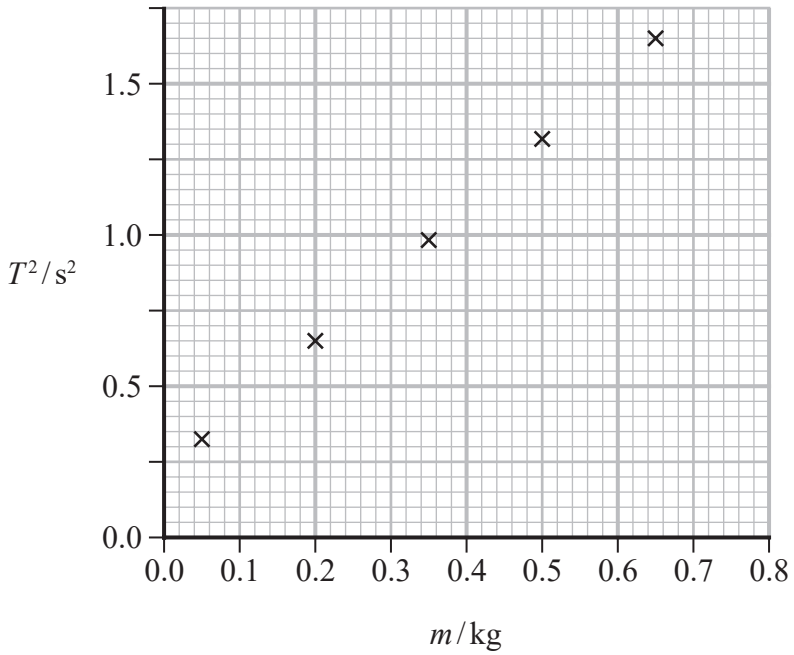
(4)

(ii) Explain how the student could modify his method in order to obtain more accurate values for the extensions of the spring.

(5)

(b) In another experiment, the student displaced the mass vertically each time a mass was added to the spring. He used a stopwatch to determine the period of vertical oscillations of each mass.

The student used his data to plot a graph of T^2 against m as shown.



The student expected the graph to be a straight line through the origin. He thought that there may be systematic error due to reaction time.

(i) Give an example of another possible systematic error in this experiment.

(1)

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(ii) Another student suggests that to reduce the uncertainty in the value for the period, a data logger connected to a light gate could be used to measure time.

Comment on the student's suggestion.

(3)

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(iii) Determine a value for the stiffness of the spring.

(3)

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Stiffness of spring = ...

(c) When determining the period of oscillation for each mass, the student measured the time for 20 oscillations. He repeated this measurement to obtain a mean time for 20 oscillations.

Explain how the student's procedure contributed to the accuracy of the measurement.

(3)

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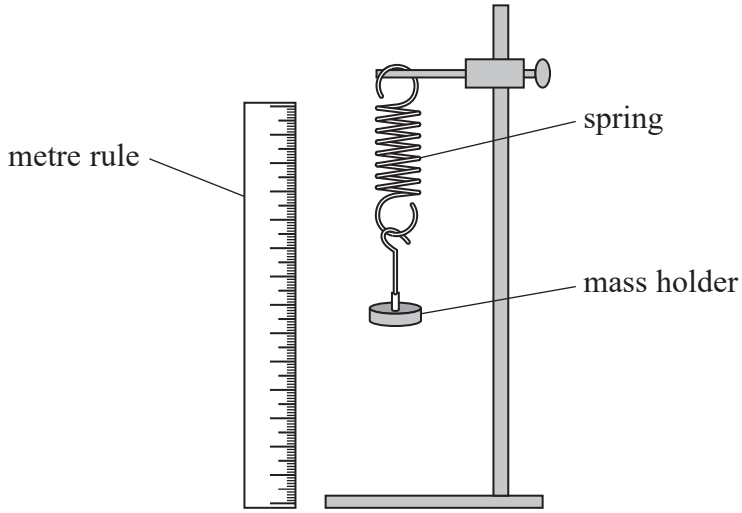
(Total for Question 10 = 19 marks)

Answer ALL questions in the spaces provided.

1 A student investigated the behaviour of a spring under tension. The spring was hung vertically with a mass holder attached, as shown. The position of the bottom of the mass holder was determined using a metre rule.



(a) The position of the bottom of the mass holder was recorded. The spring was stretched by adding masses to the mass holder and the new positions were determined. The extension of the spring for each mass was calculated.

The results are shown in the table.

Mass / kg	Extension / m
0.05	0.019
0.10	0.042
0.15	0.058
0.20	0.085
0.25	0.1
0.35	0.14

Criticise the recording of these results.

(2)

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(b) Describe how the student should determine the extension of the spring as accurately as possible.

(3)

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(Total for Question 1 = 5 marks)