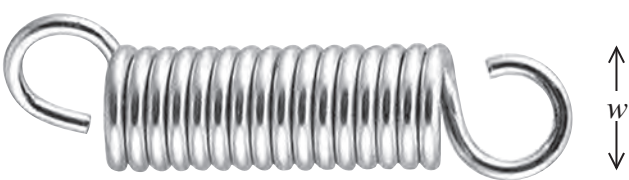


**10** A spring is made from loops of thick steel wire as shown.



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  $w$ .

$w / \text{mm}$	15.3	15.2	15.4	15.3
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- (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  $32.0 \pm 0.5$  g.

Estimate the percentage uncertainty in the mass of the spring. (1)

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

- (iv) The student calculated the density  $\rho$  of the steel using the equation

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

Calculate the percentage uncertainty in his value for the density of steel. (1)

- (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<sup>-3</sup> (4)