# HOOKE'S LAW-SPRING CONSTANT

**1** A student carried out an experiment to find the spring constant of a steel spring. The apparatus is shown in Fig. 1.1.

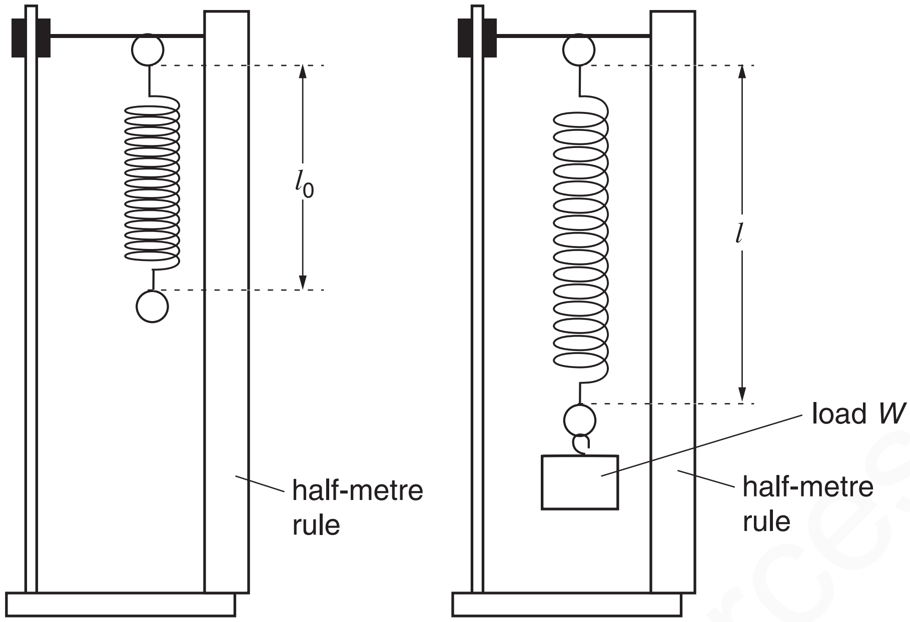



**Fig. 1.1**

The student recorded the unstretched length $l_0$ of the spring. Then she added loads $W$ to the spring, recording the new length $l$ each time. The readings are shown in the table below.

| $W$ / N | $l$ / mm | $e$ / mm |
|---|---|---|
| 0 | 30 | |
| 1 | 32 | |
| 2 | 33 | |
| 3 | 36 | |
| 4 | 39 | |
| 5 | 40 | |
| 6 | 42 | |

$l_0$ = 30 mm

**(a)** Calculate the extension $e$ of the spring produced by each load, using the equation

$$e = (l - l_0).$$

Record the values of $e$ in the table. [2]

**(b)** Plot the graph of $e$ / mm ($y$-axis) against $W$ / N ($x$-axis). [4]

**(c)** Draw the best-fit straight line for the points you have plotted. Calculate the gradient of the line. Show clearly on the graph how you obtained the necessary information.

gradient = ………………………………..[4]

| | | |
|---|---|---|
| **(a)** | Seven correct values: 0, 2, 3, 6, 9, 10, 12 (-1 each error) | 2 |
| **(b)** | Graph: | |
| | Scales, labelled, suitable size | 1 |
| | Axes, right way round | 1 |
| | Plots to ½ sq (-1 each error) | 2 |
| **(c)** | Line shape | 1 |
| | Line thickness | 1 |
| | Triangle greater than ½ line and method used | 1 |
| | Correct interpolation to ½ sq | 1 |
| | **TOTAL** | **10** |

**2** A student is determining the spring constant $k$ of a spring.

Fig. 1.1 shows the apparatus used.

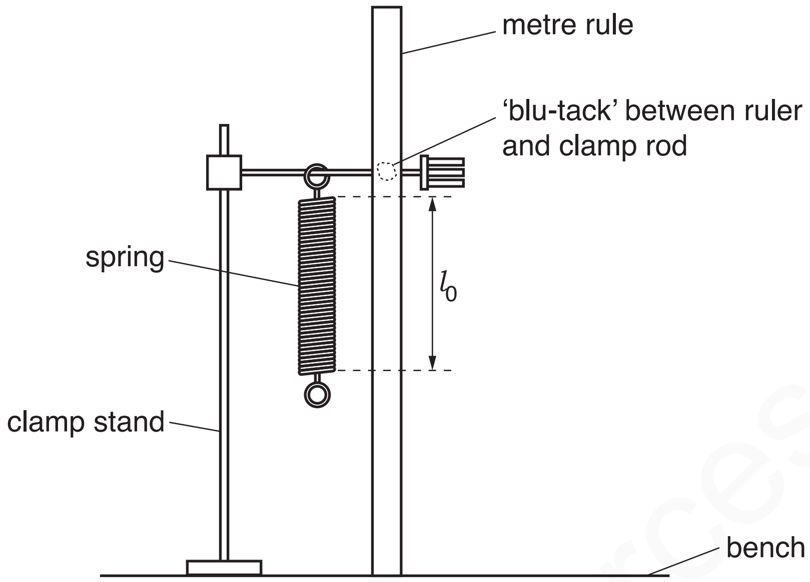



**Fig. 1.1**

**(a)** On Fig. 1.1, measure the unstretched length $l_0$ of the coiled part of the spring, in mm.

Record this value of length $l$ in Table 1.1 for $L = 0.00$ N. [1]

**(b)** On Fig. 1.1, show how a set-square could be used to take readings in order to determine the length $l_0$ of the coiled part of the spring. [1]

**(c)** The student places a 0.20 N load on the spring. He records the new length $l$ of the spring in Table 1.1.

He repeats the procedure using loads of 0.40 N, 0.60 N, 0.80 N and 1.00 N. All the readings are recorded in Table 1.1.

**(i)** Calculate the extension $e$ of the spring for each value of load $L$, using the equation

$e = (l - l_0)$. Record the values of $e$ in Table 1.1. [1]

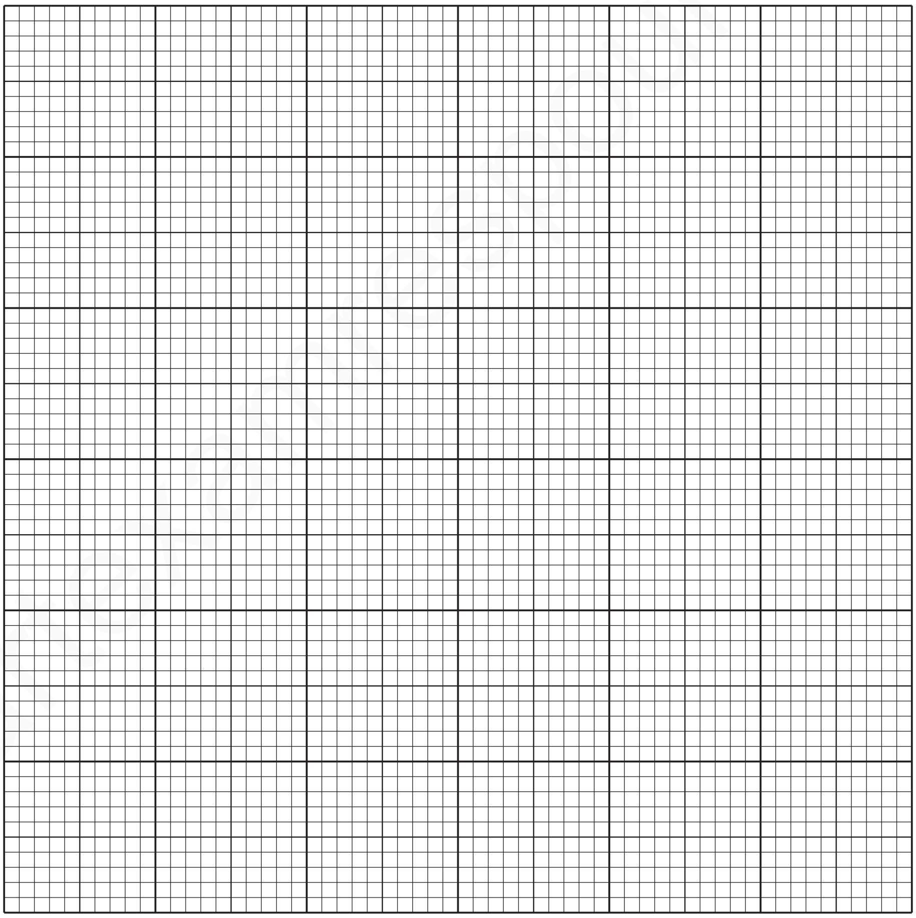
**(ii)** Complete the column headings in Table 1.1.

**Table 1.1**

| $L$/ | $l$/ | $e$/ |
|---|---|---|
| 0.00 | | 0 |
| 0.20 | 31 | |
| 0.40 | 40 | |
| 0.60 | 46 | |
| 0.80 | 55 | |
| 1.00 | 63 | |

[1]

**(d)** Plot a graph of $L$/N ($y$-axis) against $e$/mm ($x$-axis).



[4]

**(e)** Determine the gradient $G$ of the graph. Show clearly on the graph how you obtained the necessary information.

$G$ = .......................................................... [2]

**(f)** The gradient $G$ is numerically equal to the spring constant $k$.

Write down a value for $k$ to a suitable number of significant figures for this experiment.

$k$ = ............................................. N/mm [1]

[Total: 11]

# MARKING SCHEME

| | | |
|---|---|---|
| 1(a) | $l_0$ = 23 (mm) | **1** |
| 1(b) | recognisable set-square shown from spring to rule along one of the dotted lines | **1** |
| 1(c)(i) | *e* values 8, 17, 23, 32, 40 | **1** |
| 1(c)(ii) | N, mm, mm | **1** |
| 1(d) | Graph: | |
| | axes correctly labelled and right way round | **1** |
| | suitable scales, at least ½ the grid used | **1** |
| | all plots correct to ½ small square | **1** |
| | good line judgement, thin, continuous line | **1** |
| 1(e) | triangle method used and seen on graph | **1** |
| | at least half of candidate's line used | **1** |
| 1(f) | answers within the range 0.025 ± 0.005 (N / mm) and expressed to 2 / 3 significant figures only | **1** |

**3** A student is determining the spring constant *k* of a spring by two methods.

Fig. 1.2 shows how the apparatus is used.

**Method 1**

**(a)** On Fig. 1.1, measure the unstretched length $l_0$ of the spring, in mm.

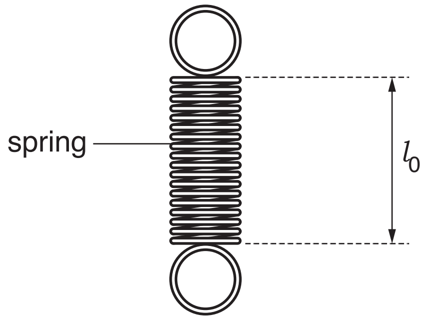



**Fig. 1.1**

$l_0$ = ................................................ mm [1]

**(b)** The student attaches the spring to the clamp as shown in Fig. 1.2.

He hangs a 300 g mass on the spring.

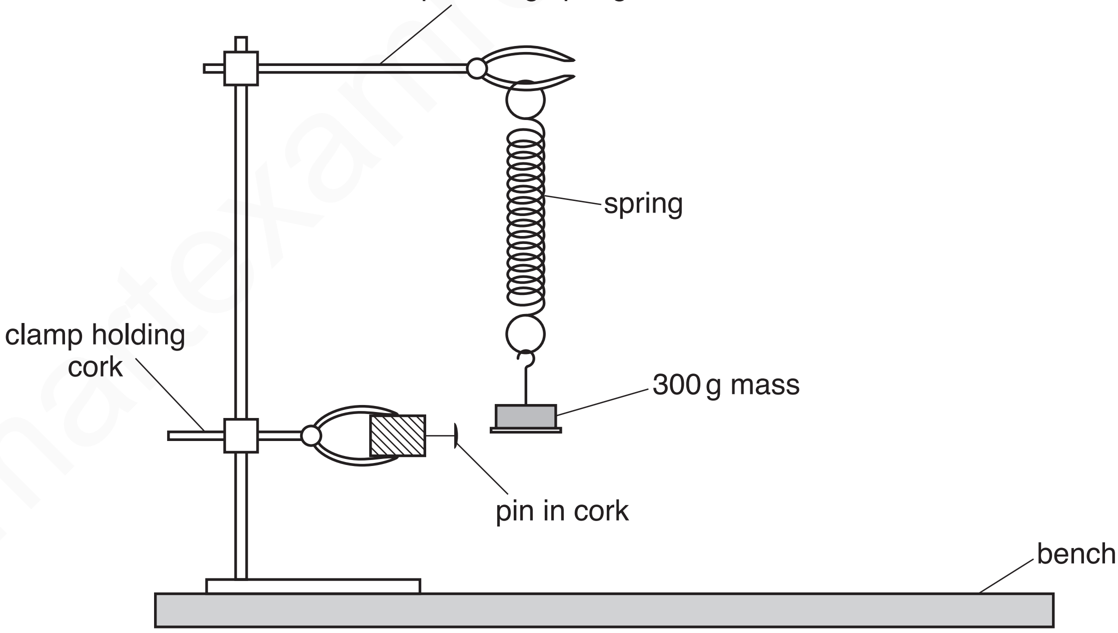



**Fig. 1.2**

He measures the new length $l$ of the spring.

$l$ = ..........................53........................ mm

**(i)** Calculate the extension $e$ of the spring using the equation $e = l - l_0$.

$e$ = ................................................ mm [1]

**(ii)** Calculate a value for the spring constant $k$ using the equation $k = \frac{F}{e}$, where $F = 3.0\,N$.

$k$ = ............................................ N/mm [1]

**Method 2**

**(c)** The student pulls the mass down a short distance and releases it so that it oscillates up and down. Fig. 1.3 shows the time $t$ taken for 10 complete oscillations.


**Fig. 1.3**

**(i)** Record the time $t$ taken for 10 complete oscillations.

$t$ = ........................................................ [1]

**(ii)** **1.** Calculate the time $T$ taken for one complete oscillation.

$T$ = ...........................................................

**2.** Calculate $T^2$.

$T^2$ = ...........................................................
[2]

**(iii)** Calculate the spring constant $k$ using the equation $k = \frac{0.040\,m}{T^2}$, where $m = 0.300\,kg$.

$k$ = ............................................ N/mm [1]

**(d)** State and explain whether your two values for *k* are the same within the limits of experimental accuracy.

statement ..........................................................................................................................

explanation ........................................................................................................................

.......................................................................................................................................... [2]

**(e)** A student states that repeating Method 1 with different masses would improve the reliability of the value obtained for *k*.

Suggest additional values for the mass *m* that you would use when repeating the experiment to improve the reliability.

..........................................................................................................................................

..........................................................................................................................................

.......................................................................................................................................... [2]

[Total: 11]

# MARKING SCHEME

| | | |
|---|---|---|
| 1(a) | $l_0 = 22$ (mm) | 1 |
| 1(b)(i) | $e = 31$ (mm) ecf allowed | 1 |
| 1(b)(ii) | $k = 0.0968$ (N / mm) ecf allowed | 1 |
| 1(c)(i) | $t = 3.46$ (s) | 1 |
| 1(c)(ii) | $T = 0.346$ (s) $T^2 = 0.12$ (0.1197) | 1 |
| | units s and $s^2$ | 1 |
| 1(c)(iii) | $k = 0.1$ | 1 |
| 1(d) | Statement matches results | 1 |
| | Idea of within (or beyond) limits of experimental accuracy explained, e.g. close (enough), very close, nearly the same; (too) far apart | 1 |
| 1(e) | At least 3 additional values given | 1 |
| | Values between 50 g and 600 g | 1 |