SMART EXAM RESOURCES
0654 COORDINATED SCIENCES
PHYSICS
FORCES-SET-5-QP-MS

MEASURING SPRING CONSTANT

1 A student measures the spring constant k of a spring by two different methods.

The spring constant k of a spring is a measure of how difficult the spring is to stretch.

(a) **Method 1**

The student:

- measures the unstretched length l_0 of the spring
- attaches the spring to a clamp
- suspends a mass m = 300 g on the spring as shown in Fig. 5.1
- measures the new, stretched length l_1 of the spring.

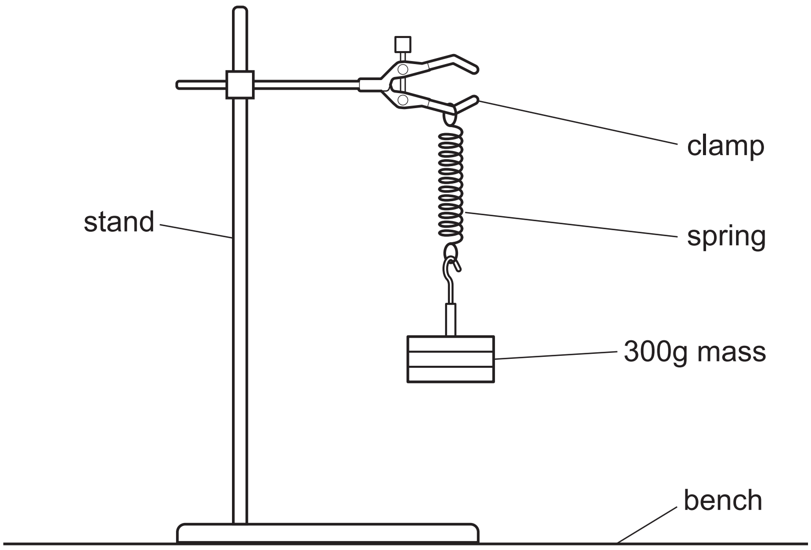

Fig. 5.1

Fig. 5.2 is a full size diagram showing the unstretched spring and the spring when it has been stretched by the 300 g mass.

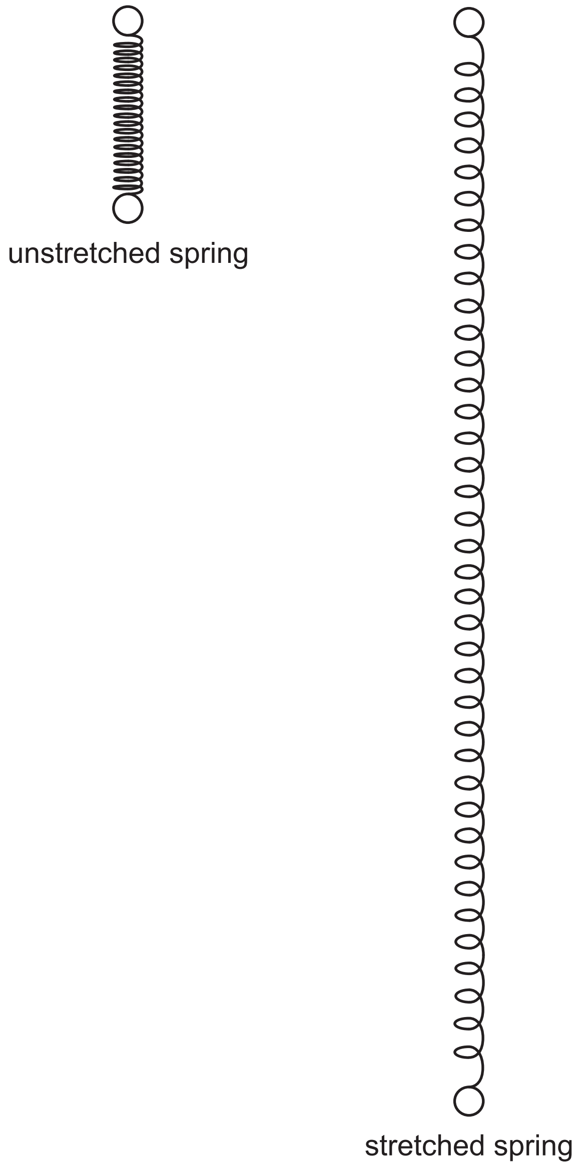

Fig. 5.2

(i) Measure the unstretched length l_0 of the spring in centimetres to the nearest 0.1 cm.

Do **not** include the loops at the end of the spring in your measurement.

l_0 = ... cm [1]

(ii) Measure the new length l_1 of the spring in centimetres to the nearest 0.1 cm.

Do **not** include the loops at the end of the spring in your measurement.

l_1 = ... cm [1]

(iii) Calculate the extension *e* of the spring produced by the mass.

Use the equation shown.

$$e = l_1 - l_0$$

e = ... cm [1]

(b) (i) It is important to avoid a line-of-sight (parallax) error when measuring the length of a spring.

Describe **one** way the student avoids this error.

....

.... [1]

(ii) Stretched springs are potentially dangerous because of the elastic energy stored in them.
State **two** safety precautions that the student takes when doing the experiment. Explain how each precaution reduces the risk.

1 ....

....

2 ....

....
[2]

(c) Calculate a value k_1 for the spring constant of the spring.

Use the equation shown.

$$k_1 = \frac{W}{e}$$

where *W*, the weight of the 300 g mass = 3.0 N.

k_1 = ... N/cm [1]

(d) **Method 2**

The student:

- pulls the mass down a small distance and releases it so that the mass oscillates up and down
- measures the time taken t_1 for 20 oscillations of the mass.

Fig. 5.3 shows the reading on the stop-watch.

Fig. 5.3

Record the time taken t_1 in Table 5.1.

Table 5.1

mass/g	time for 20 oscillations/s			average time for 20 oscillations t_{av}/s	average period T_{av}/s
	t_1	t_2	t_3		
300		14.4	14.1		

[1]

(e) The student repeats **Method 2** two more times and records the times t_2 and t_3 in Table 5.1.

(i) Calculate the average time t_{av} for 20 oscillations of the mass.

Use the equation shown.

$$t_{av} = \frac{(t_1 + t_2 + t_3)}{3}$$

Record your answer in Table 5.1. [1]

(ii) State why repeating the timing and calculating the average time for 20 oscillations is good experimental practice.

....

.... [1]

(f) Calculate the average period T_{av} of the oscillations. The period is the time for one oscillation of the mass.

Record your answer in Table 5.1. [1]

(g) Calculate a value k_2 for the spring constant of the spring.

Use the equation shown.

$$k_2 = \frac{0.12}{(T_{av})^2}$$

k_2 = ... N / cm [1]

(h) **(i)** Use your answers to **(c)** and **(g)** to calculate $(k_1 - k_2)$, the difference between your two measured values of k.

$(k_1 - k_2)$ = ... N / cm [1]

(ii) State whether or not the difference in the values of k_1 and k_2 allows the values to be considered equal within the limits of experimental accuracy.

Explain your answer.

statement ....

explanation ....

....
[1]

[Total: 14]

MARKSCHEME:

(a)(iii)	*e* = 11.8 (cm) ;	1
(b)(i)	view perpendicular / at eye level to scale / rule close to spring / use of set square / fiducial aid ;	1
(b)(ii)	*any two from:* wear goggles to protect (delicate) eyes from flying / rebounding springs ; place a weight on the stand base to prevent it toppling over (stability) ; wear shoes to protect against (heavy) weights falling onto feet/toes ;	2
(c)	k_1 = 0.25 (N / cm) ;	1
(d)	14.2 (s) ;	1
(e)(i)	14.2(3) ;	1
(e)(ii)	spots anomalous results / increases the reliability ;	1
(f)	0.71 (s) ;	1
(g)	k_2 = 0.24 (N / cm) ;	1
(h)(i)	0.01 (N / cm) ;	1
(h)(ii)	(expect) YES and difference very small / close to zero / insignificant / less than 10 % ;	1

INVESTIGATING STRETCHING OF SPRINGS

2 A student investigates the stretching of a spring.

The student assembles the spring and a metre rule as shown in Fig. 5.1.

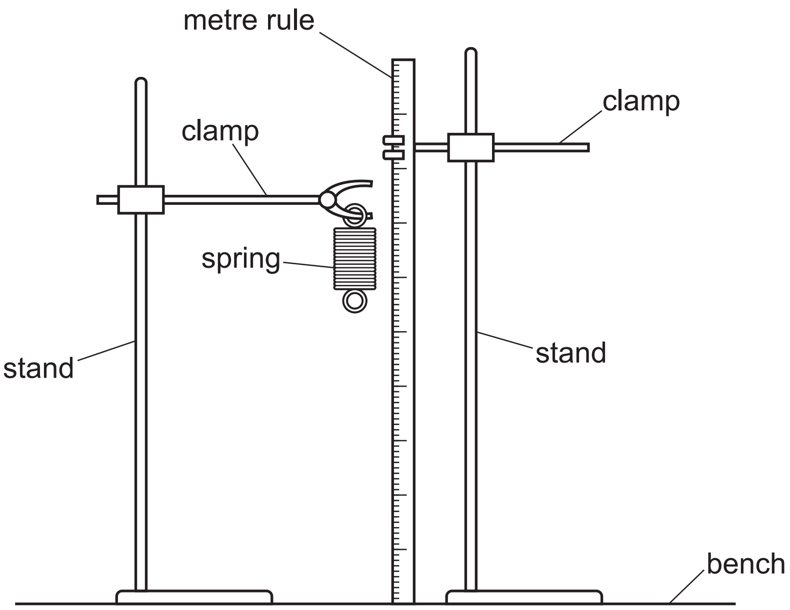

Fig. 5.1 (not to scale)

Fig. 5.2 shows a full-size diagram of the unstretched spring and part of the metre rule.

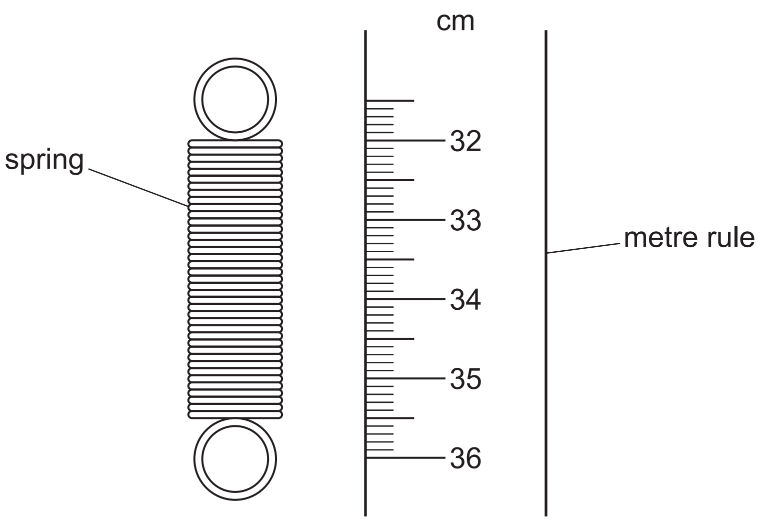

Fig. 5.2

(a) **(i)** Take readings from the metre rule of the top and the bottom of the coiled part of the spring. Do **not** include the loops at the ends of the spring.

Record your readings to the nearest 0.1 cm.

reading of top of spring = ... cm

reading of bottom of spring = ... cm
[2]

(ii) Calculate the length l_0 of the coiled part of the spring.

Show your working.

Record in Table 5.1 this value of l_0 for load L = 0.0 N.

Table 5.1

load L / N	0.0	1.0	2.0	3.0	4.0	5.0
length l / cm		6.3	1.9	11.9	14.7	17.5

[1]

(b) **Procedure**

The student:

- places a load L = 1.0 N on the spring
- records in Table 5.1 the length l of the coiled part of the spring
- repeats this procedure for load L = 2.0 N, 3.0 N, 4.0 N and 5.0 N.

The student records the length l of the coiled part of the spring, produced by one of the loads, incorrectly.

State for which load the incorrect length has been recorded.

load = ... N

Deduce the length that the student should have recorded.

length .... cm
[2]

(c) Line of sight (parallax) errors can occur when readings are taken from the metre rule.

State two practical precautions that the student takes to ensure that accurate readings are taken from the metre rule.

precaution 1 ....

....

precaution 2 ....

.... [2]

(d) Another student suggests that the stretched length l of the spring is proportional to load L.

State if the readings support this suggestion.

Use values from Table 5.1 to justify your answer.

statement ....

justification ....

.... [1]

(e) A student wants to stretch the spring to four times the length l_0 of the unstretched spring.

Use the results in Table 5.1 to predict the load L the student needs to add to the spring.

predicted load L = ... N [1]

(f) Stretched springs are potentially dangerous because of the elastic energy stored in them.

State **and** explain **one** safety precaution that the student takes when doing the experiment.

precaution ....

explanation ....

.... [1]

[Total: 10]

MARKSCHEME:

(a)(i)	32.0 ; 35.5 ;	2
(a)(ii)	3.5 ;	1
(b)	2(.0) ; 9.1 ;	2
(c)	*any **two** from:* view reading at eye level / perpendicular to rule ; place rule close / parallel to the spring ; use of a fiducial aid e.g., set-square ;	2
(d)	NO and doubling *L* does not double / (or similar) / the ratio *l* / *L* / *L* / *l* is not constant ;	1
(e)	3.5 – 3.9 inclusive ;	1
(f)	wear goggles to protect the eyes in case the spring breaks / comes loose / flies off / place a heavy load on the base of the stand to protect feet / hands / legs in case topples over / steel toe cap shoes protects feet from loads falling from spring / spring breaks ;	1