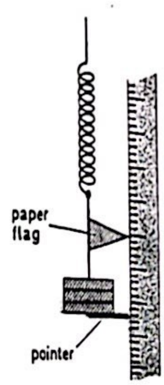
# Experiments with a spiral spring

**Apparatus** Spiral spring, stand and clamps, metre or half-metre rule, slotted masses and hanger (or scale pan and masses), stop watch.




**Experiment 1** **Statical Experiment: To verify Hooke's law and to determine the force constant of the spring, i.e. the force required to produce unit extension**

**Method** Suspend the spring so that it hangs vertically from a rigid support, and to the lower end attach the first of the slotted masses (the hanger). Clamp the scale vertically alongside the spring so that a small pointer or flag attached to the spring moves lightly against the scale. If the apparatus is not provided with a pointer, one can easily be improvised by folding a piece of gummed paper round the straight portion of the spring and cutting it to the necessary shape or alternatively by sticking a needle, by means of Sellotape or Plasticine, to the underside of the first weight.

Record the reading of the pointer and the mass attached to the spring.

Increase the load by successive increments of 10 or 20 g, and record the pointer reading each time. When about ten such readings have been taken, and before the spring has stretched to more than double its original unloaded length, start unloading the masses and again record the pointer readings.

**Readings**

| Load/g | Pointer reading/cm | | |
|---|---|---|---|
| | Load increasing | Load decreasing | Mean reading |
| | | | |

Draw a graph with the values of the mean pointer reading/cm as ordinates against the corresponding values of the load/g as abscissae.

**Experimental details**

1. If the pointer readings recorded for an increasing load are not repeated approximately when the load is decreasing, the elastic limit of the spring has been passed, and the readings for a decreasing load will have to be scrapped.

2. If it is practicable, suspend the spring from a firmer support than a clamp, e.g. use a hook driven into a wall. There is no danger then of the support yielding whereas a clamp might easily yield.



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**Theory and calculation** The graph will probably be of the shape shown in the diagram and the first conclusion to be drawn is that though most of the points lie on a straight line not all of them do and therefore the *total* extension of the spring is not proportional to the *total* load producing it. However, for the straight-line portion of the graph it is seen that any *increase* QN in the load is proportional to the extension PN it produces, which is Hooke's law.

The *mass* to produce unit extension

$$= \frac{QN\,g}{PN\,cm} = \frac{QN \times 10^{-3}\,kg}{PN \times 10^{-2}\,m} = \frac{QN}{PN} \times 10^{-1}\ \text{in kg m}^{-1}.$$

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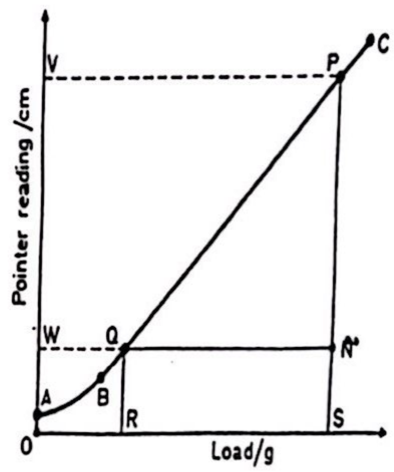
∴ the *force* to produce unit extension, i.e. the force constant $\lambda$, is

$$\lambda = \frac{QN}{PN} \times 10^{-1} \times g \text{ in N m}^{-1}$$




*Note.* The initial curved portion of the graph is probably due to the fact that in the early stages of the experiment some of the turns of the spring are pressing against each other.

**Errors and accuracy**

Assuming the correctness of the masses the only experimental error is in reading the position of the pointer on the scale. As the value for $\lambda$ is obtained solely from the slope of the graph it follows that the % error in $\lambda$ is the same as the % error in the slope. Estimate the difference between the slope of the chosen 'best' straight line through the points and the slope of other possible straight lines drawn through the points and express this is a percentage (as described on p. 11).

State your result for the force constant accordingly.

**Addition**

From the graph, the work done in stretching the spring any given amount can be calculated, by considering the equation Work = Force × Distance (and for a varying force Work = $\int F\,ds$) it is seen to be the area between the graph and the *axis of extension* between the given limits.

Thus the work done in increasing the extension from QR to PS is the area PVWQ.

$$\begin{aligned} \therefore \text{work done} &= \tfrac{1}{2}(PV+QW)g \times VW\,cm \\ &= \tfrac{1}{2}(PV+QW) \times 10^{-3}\,kg \times VW \times 10^{-2}\,m \\ &= \tfrac{1}{2}(PV+QW) \times VW \times 10^{-5}\,kg\,m \\ &= \tfrac{1}{2}(PV+QW) \times VW \times 10^{-5} \times g \text{ in N m}^{-1}\text{, i.e. in J.} \end{aligned}$$

*Experimental 2 and 3. See overleaf*