

Hooke's law

Starter

1. (Review of last lesson)

A particle moves under the resistive force given by $f(x) = 4x \ln 2x$ from the point where $x = 1$ to the point where $x = e$. Calculate the work done against the resistive force.

Notes

For a string or spring:

force \propto extension (stretching)

force \propto compression (compressing)

Hooke's law: the tension in a string or spring is given by $T = \frac{\lambda x}{l}$

where x is compression/extension of spring or extension of string

l is the natural length of the spring or string

λ is the modulus of elasticity (measured in Newtons)

The **modulus of elasticity** is the **force required to double the length of the spring**, given that the extension does not exceed its elastic limit.

N.B. Small λ means the spring is flexible (easy to extend/compress)
Large λ means the spring is stiff (difficult to extend/compress)

E.g. 1 A light elastic string of natural length 0.7 m and modulus of elasticity 50 N has one fixed end and a particle of mass 1.4 kg attached to the other. The system hangs vertically in equilibrium. Find the extension of the string.

Working: $l = 0.7, \lambda = 50, T = 1.4g$

$$\text{Substituting into } T = \frac{\lambda x}{l}: \quad 1.4g = \frac{50x}{0.7}$$
$$x = 0.19208 \text{ m}$$

The extension of the string is 19.208 cm

E.g. 2 A set of kitchen scales consists of a light scale pan supported on a spring of natural length 8 cm. When measuring 1.5 kg of flour the spring is compressed by 7 mm. Find:

- the modulus of elasticity
- the mass of the heaviest object that can be measured if it is impossible to compress the spring by more than 15 mm.

E.g. 3 A light spring has modulus of elasticity λ N and natural length l m. One end is attached to a ceiling, the other to a particle of mass m kg which hangs in equilibrium below the ceiling. In this situation the total length of the string is L m. When $m = 0.03, L = 0.49$, and when $m = 0.06, L = 0.53$.

- Find the value of l and the value of λ .
- Find the value of m when $L = 0.6$.

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Exercise

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Summary

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