HOOKE'S LAW

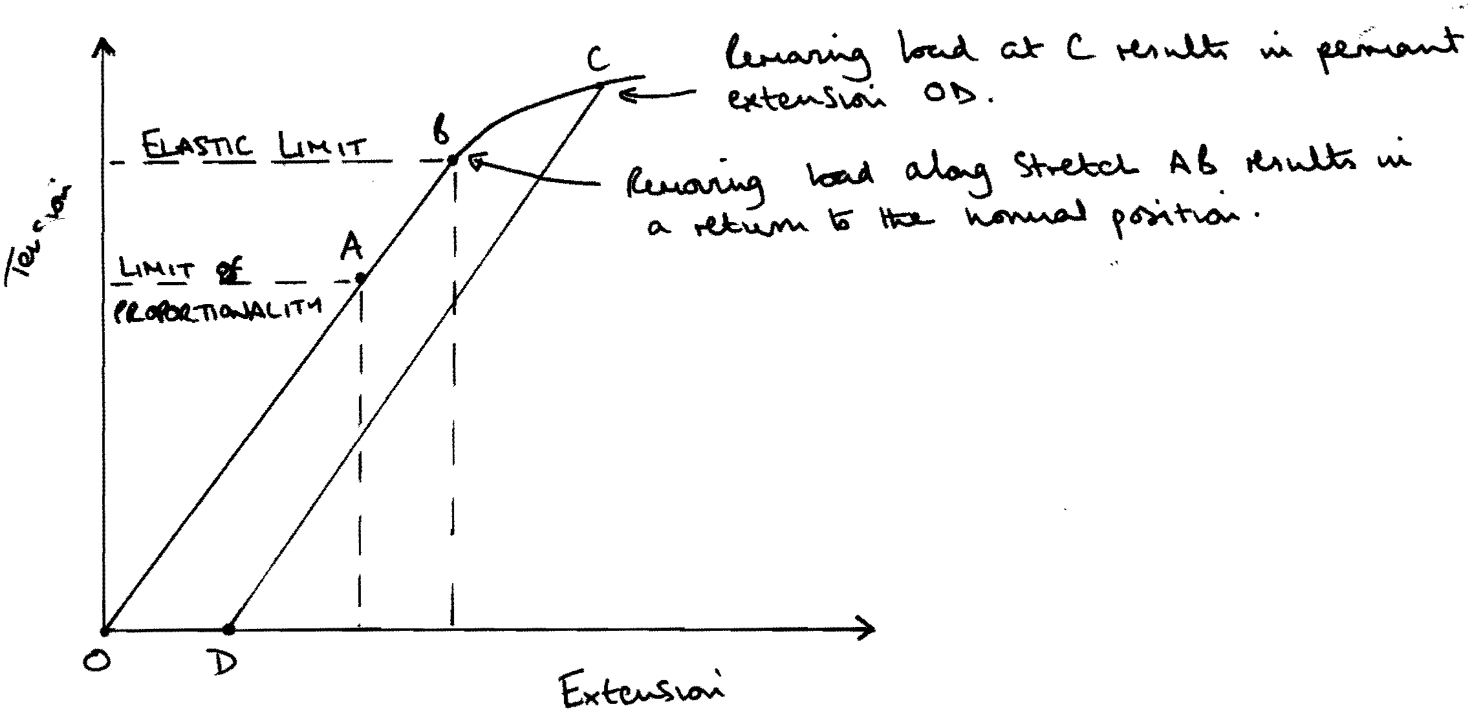
For many objects the force F required to maintain an extension, x, is directly proportional to the extension.

$F \propto x$ which gives $F = kx$

Where k is the spring constant and is a measure of the 'Stiffness' in $N m^{-1}$

Hooke's Law is usually ~~obeyed~~ obeyed up to some maximum value of the applied force, and beyond that the relation between force and extension is 'non-linear'.

STRETCHING A HELICAL STEEL SPRING:



Spring Constant: $k = \frac{F}{x}$ equal gradient of graph in the linear region.

Limit of Proportionality: beyond this point (A) the graph is non-linear.

Elastic behaviour: means that the ~~load~~ spring returns to zero extension when the load is removed.

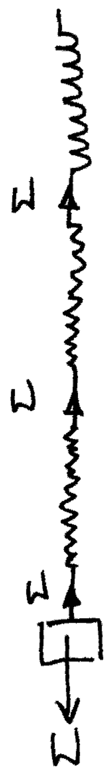
Elastic Limit: beyond this point (B) the spring suffers permanent deformation, and does not return to zero extension when the load is removed.

Plastic Deformation: permanent structural change, after which the spring will not return to zero extension when the load is removed.

In the elastic region, the applied forces extend the bonds between particles in the material. Permanent or plastic deformation occurs when bonds break and particles move &/ or flow past one another to new positions.

SPRINGS IN SERIES + PARALLEL.

SERIES



We know that for Hooke's law

$$F = ke$$

F = force, k = spring constant, e = extension

Having in series effectively reduces the stiffness of the system:

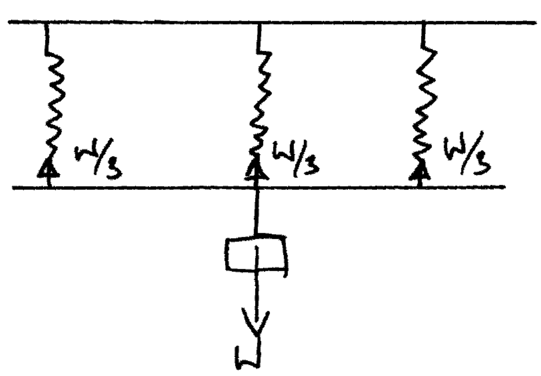
$$\text{Series} \Rightarrow \frac{k}{n}$$

$$\therefore \quad F = \frac{k}{n} \cdot e$$

$$\therefore \quad e = \frac{Fn}{k} \qquad \therefore e \uparrow \text{ factor } n$$

The arrangement is less stiff than a single spring.

PARALLEL



From Hooke's Law:

$$F = ke$$

$$\text{For parallel} \Rightarrow nk$$

$$\therefore \quad F = nke$$

$$\therefore \quad e = \frac{F}{nk} \qquad \therefore e \downarrow \text{ by factor } 1/n.$$

This system is stiffer than a single spring

Springs in series and parallel

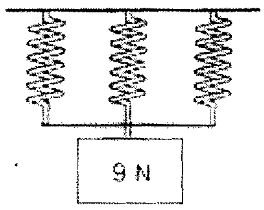


Fig. 1.1

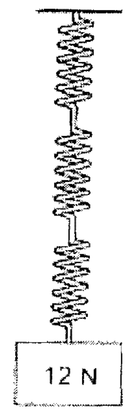


Fig. 1.2

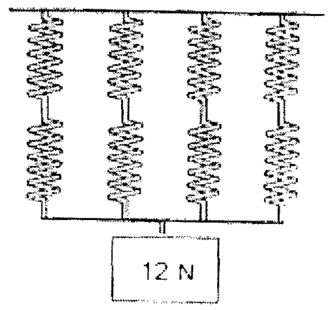


Fig. 1.3

Identical springs are used in the arrangements shown above. The diagrams are not shown to scale, and the unstretched lengths of the springs are in fact different in the four diagrams. In Fig. 1.1, the 9 N weight hangs 1.5 cm below the unstretched position of the springs.

(a) Calculate the total extensions of the arrangements in Fig. 1.2 and 1.3 for the loads shown.

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