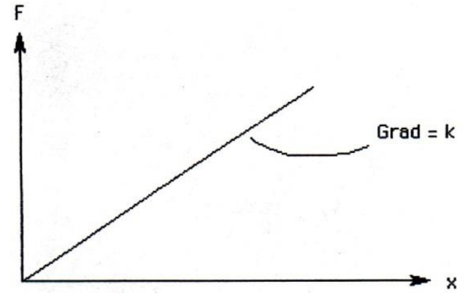
M.7.9 Strain Potential Energy

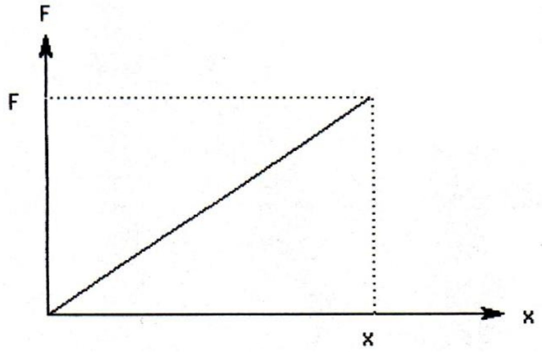
Elastic potential energy (strain energy) is the energy stored in any material that has been stretched or compressed from its normal shape.
Springs and elastic bands are good examples.

we have
Energy stored = potential energy of spring = work done on spring

In about 1675 Robert Hooke noticed that the more you stretch a spring from its natural length, the stronger the force needed.
i.e. $F \propto \Delta x$
we write $F = -k \Delta x$ Hooke's law
where k = spring constant (unit $N\ m^{-1}$)
we get a graph which looks like



Now P.E. of spring = Work done on it
We can calculate the work done on a spring in stretching it x metre from the force-distance graph.



Work done = area under graph (can't use $w = f \times x$ because force not constant)

$= \frac{1}{2} F x$

But $F = k x$

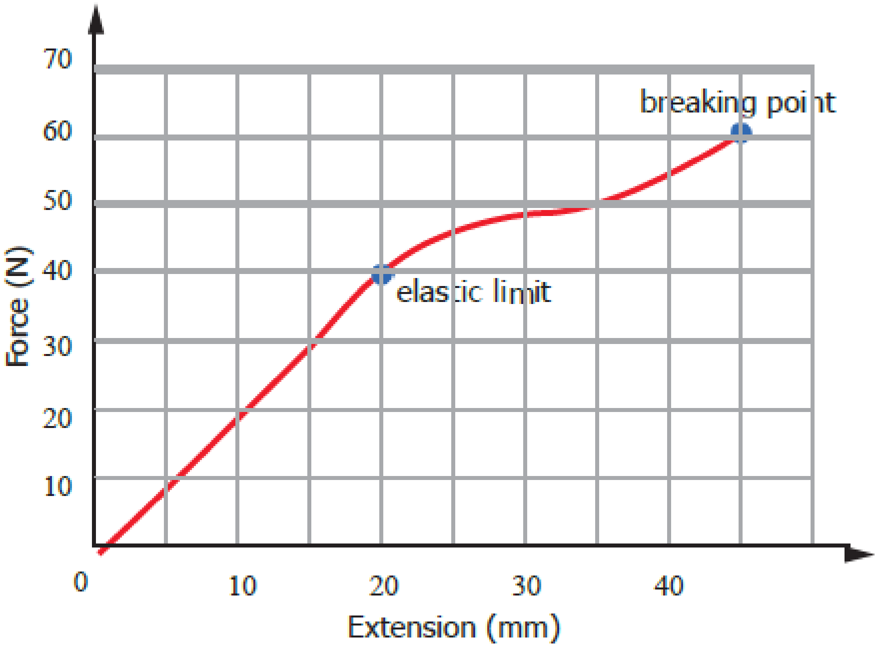
So work done $= \frac{1}{2} k \Delta x\, x$
$= \frac{1}{2} k (\Delta x)^2$

$\therefore$ U_s of spring $= \frac{1}{2} k (\Delta x)^2$ (Joule)

Note:- For a spring compressed and then released Δ P.E. (spring) = Δ K.E. (body).
Conservation of energy. E_{total} = K.E. + P.E.

Example

A fine steel wire has the force–extension properties shown in the figure below.



a. Calculate the spring constant k for the wire.
b. Calculate the strain potential energy that the wire can store before permanent deformation occurs.
c. Calculate the work done to break the wire.

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