Materials

2015 EdExcel A Level Physics

Topic 4

Hooke's Law and elastic strain energy

Physics Tutor Online

Force and Extension

Consider a mass on a spring:

Putting a mass on a spring will extend it. Keep putting the masses on and the spring will stretch further for each mass added

Does this happen to other materials?

Hooke's Law

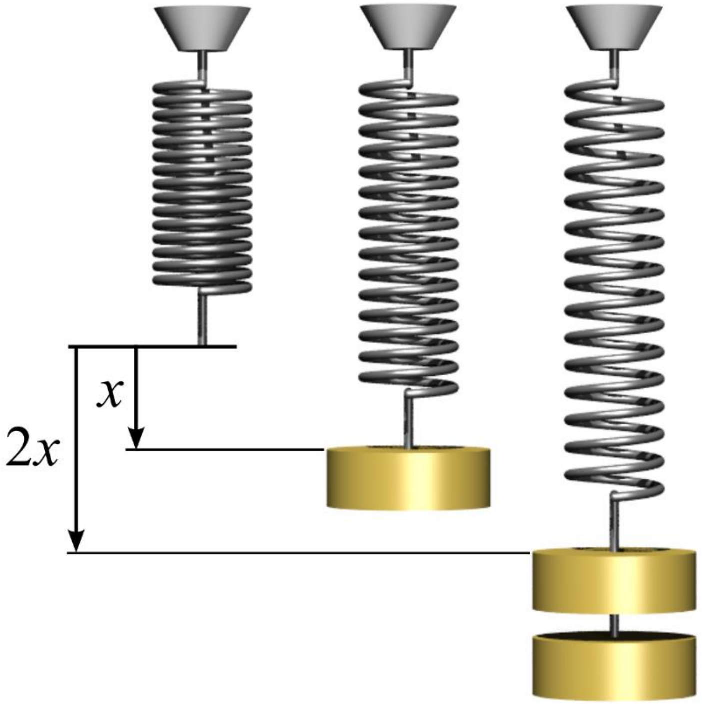
Robert Hooke
1635-1703

I found out that the force applied to a spring is proportional to the extension, within the elastic limit of the spring.

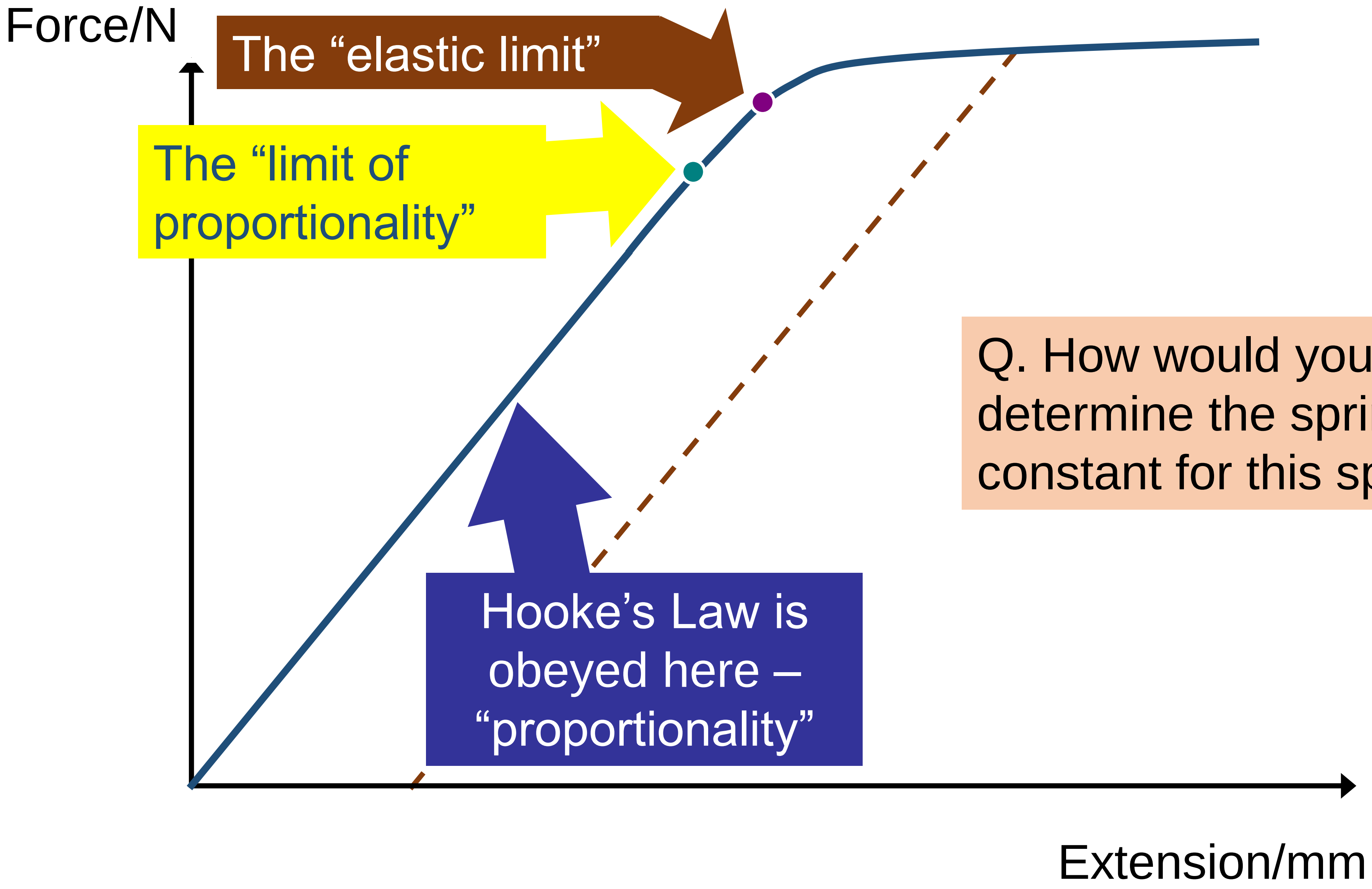
F= -k x

Where:

F = force
K = spring constant
X = displacement



Force-Extension Graph for a spring

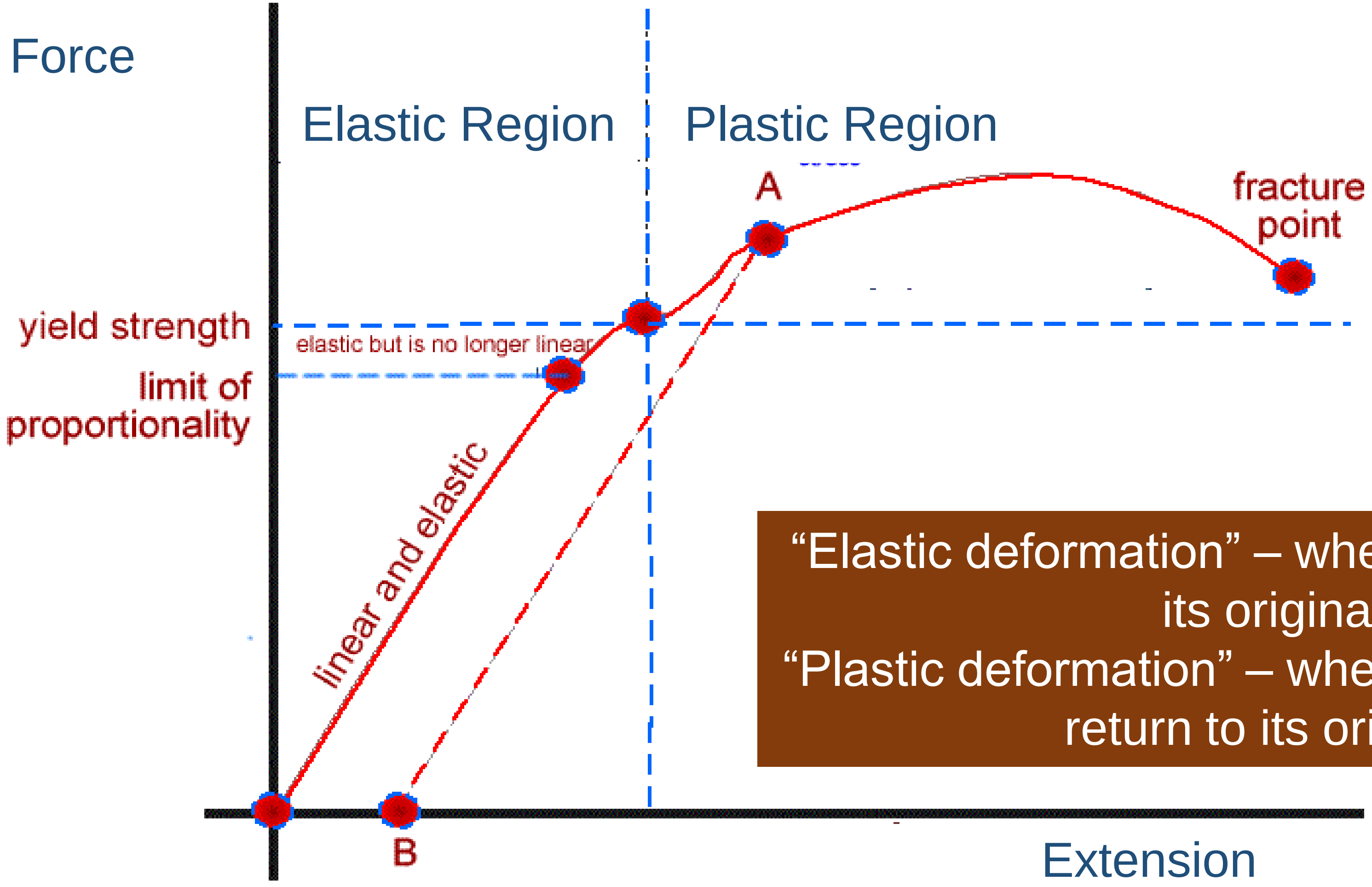


Q. How would you determine the spring constant for this spring?

Questions on the Spring Constant

1) Estimate the spring constant of a 20N Newton meter
2) Estimate the spring constant of the suspension on a car

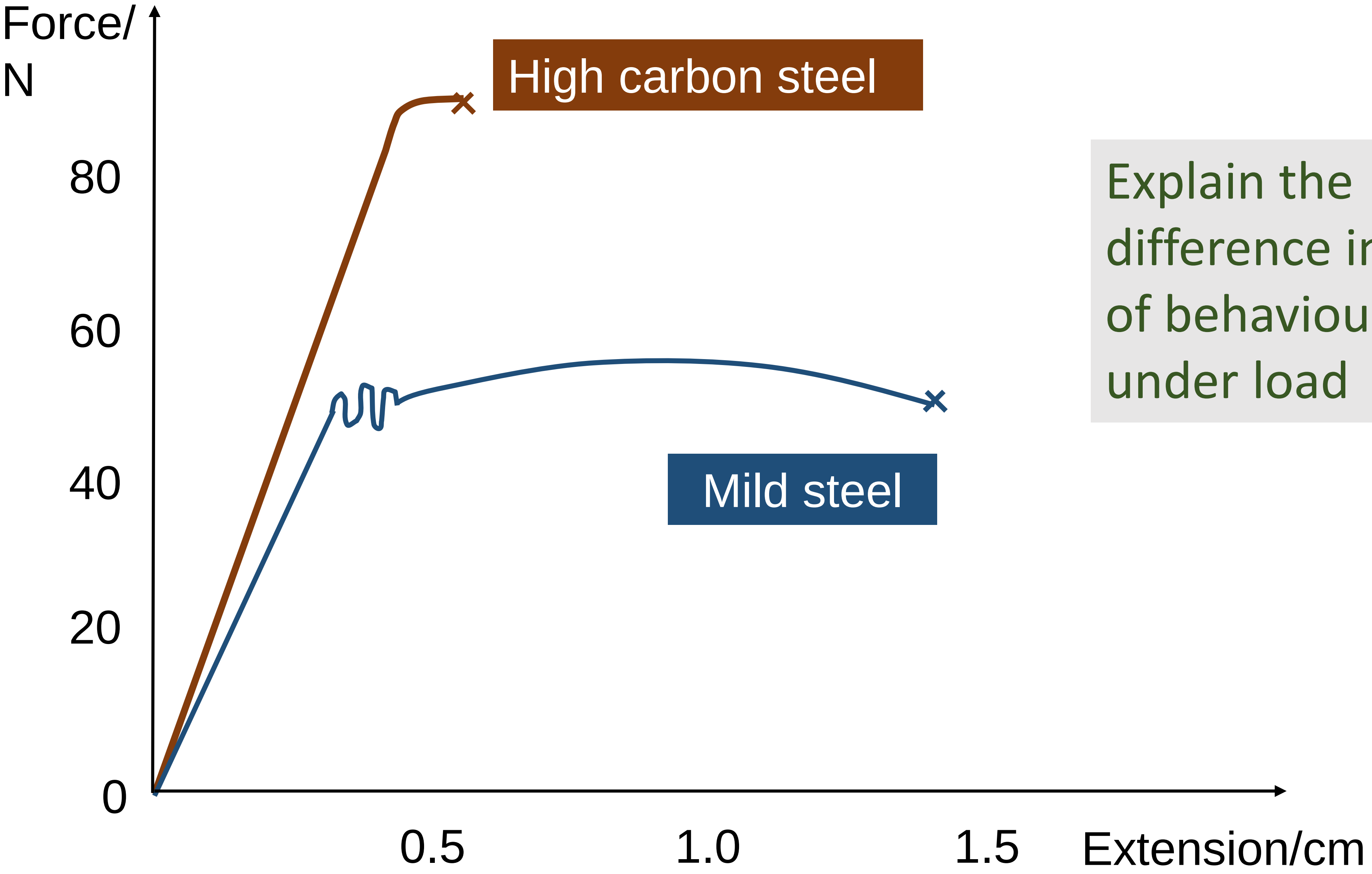
Force-Extension Graph for a wire



"Elastic deformation" – when the material returns to its original shape

"Plastic deformation" – when the material does NOT return to its original shape

Force-Extension Graph for steel



Explain the difference in terms of behaviour when under load

Force and compression

Consider some springs:

The force-compression and stress-strain graphs for objects like these can be determined and plotted.

Example questions:

1) A stiff spring has a spring constant of $20Nm^{-1}$. How much will it compress by if a force of 40N is applied to it?

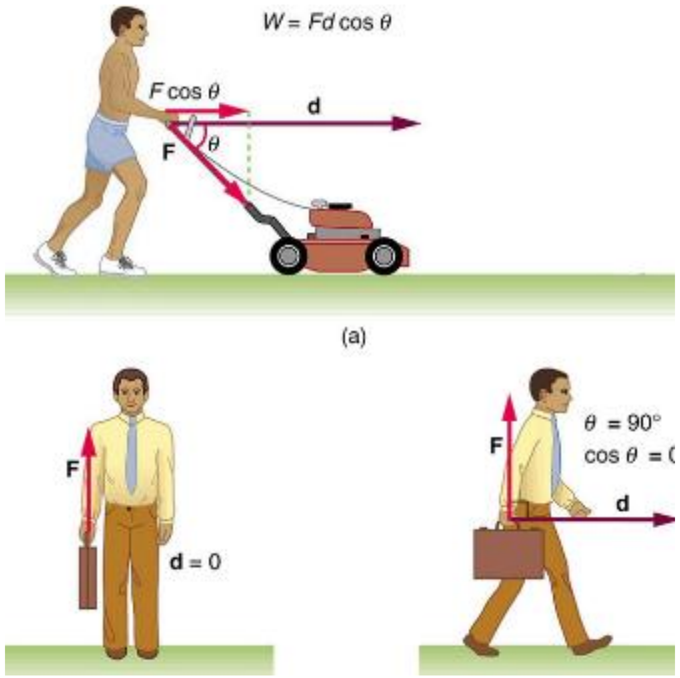
2) Estimate the stress on the lower bones in your leg when you are standing up.

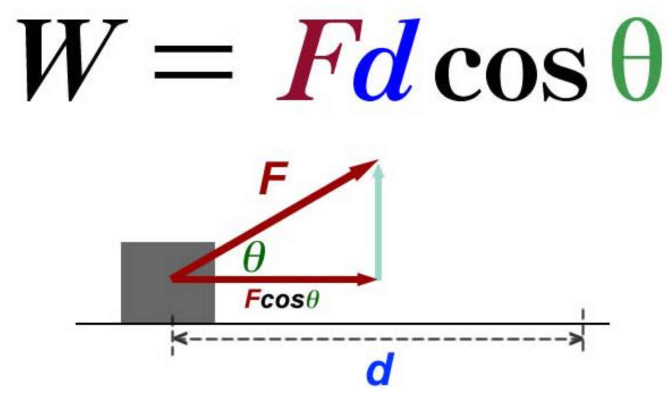
Micrometer screw gauge

Micrometers are more accurate and can be used to measure the width or depth of an object to a precsion of 0.01mm…

Work done recap

Work done (in joules) is simply the force needed to move an object multiplied by the distance moved in the direction of the force:





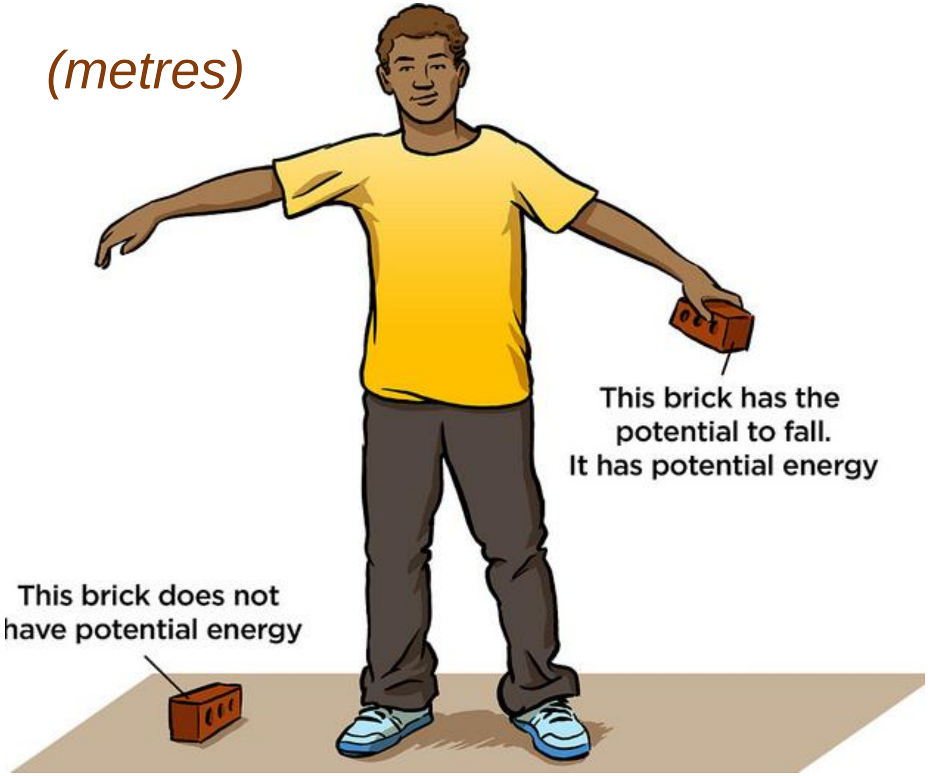
Gravitational Potential Energy recap

To work out how much gravitational potential energy (GPE) an object gains when it is lifted up we would use the simple equation…

GPE = Weight x Change in height

(Joules) *(newtons)* *(metres)*

(Remember - W=mg)



Kinetic energy recap

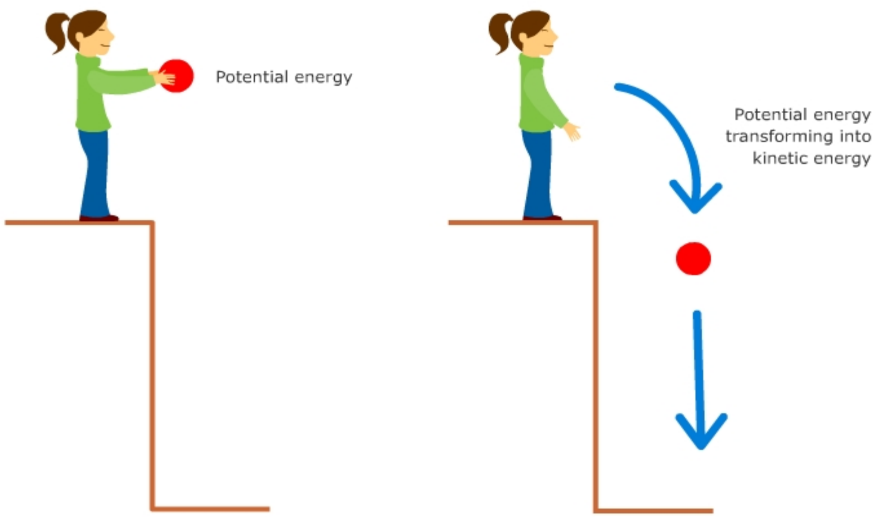
Any object that moves will have kinetic energy.

The amount of kinetic energy an object has can be found using the formula:

Kinetic energy = ½ x mass x velocity squared

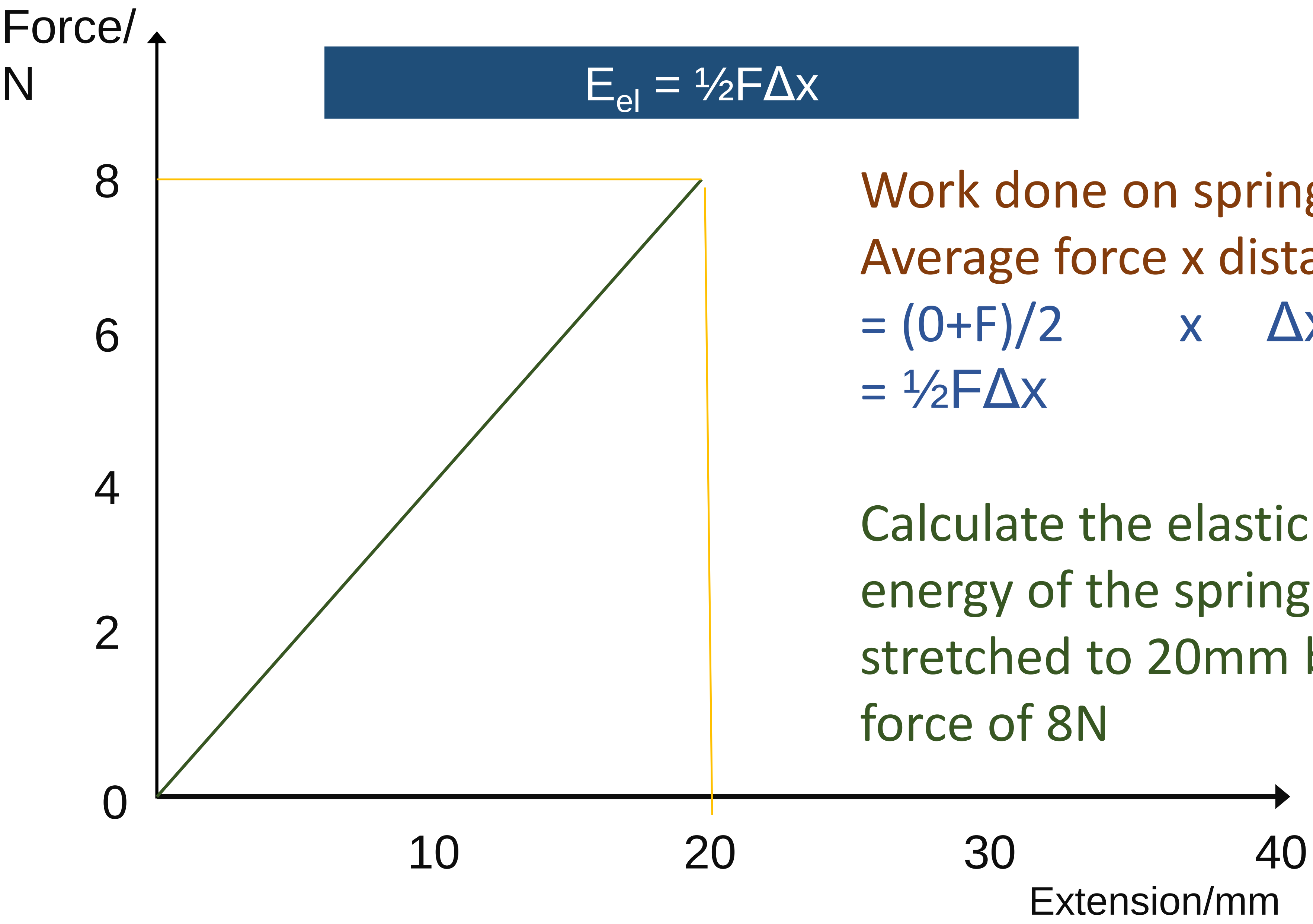
in J *in kg* *in m/s*

$$E_k = \frac{1}{2} m v^2$$



Elastic Strain Energy

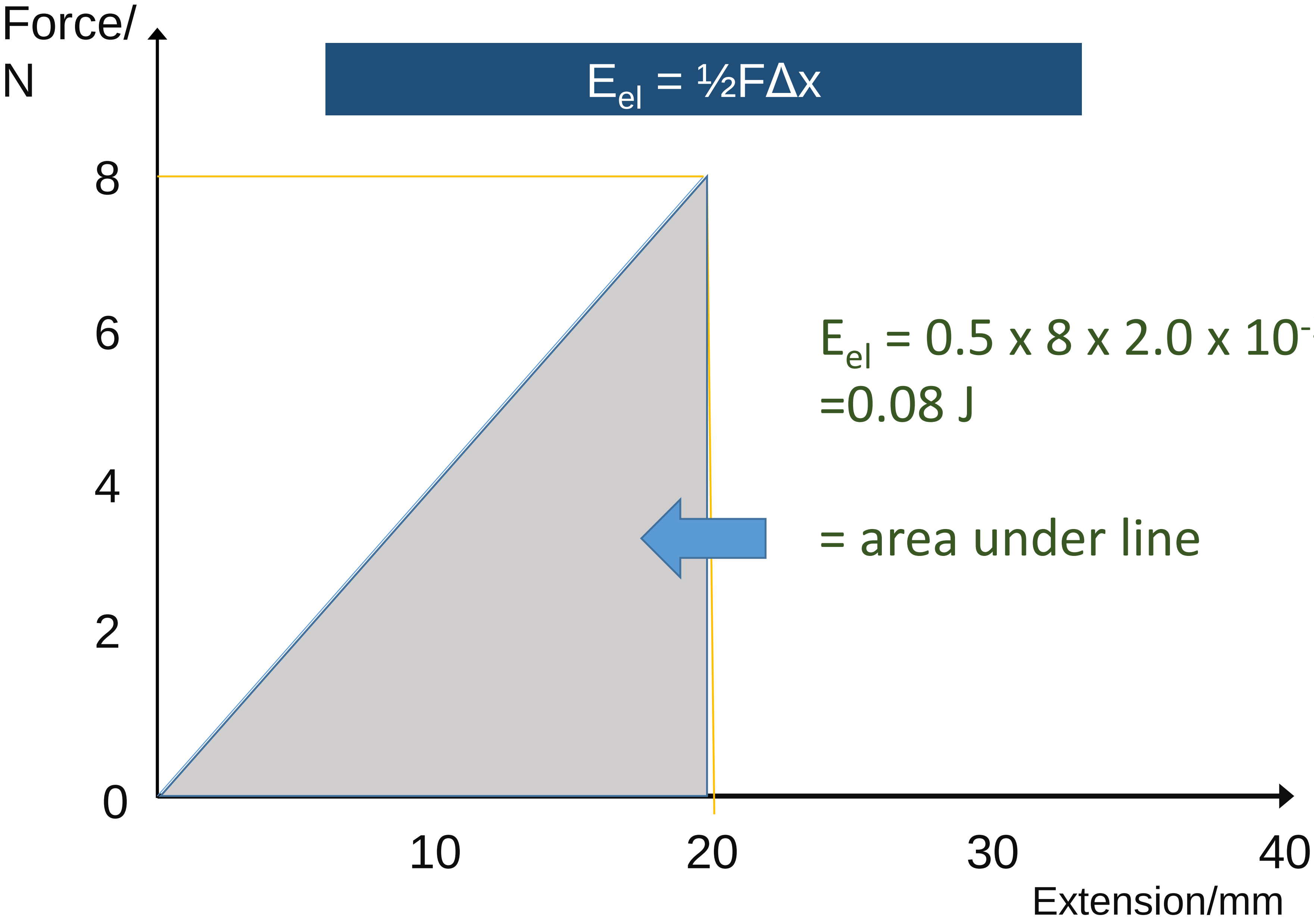
$E_{el} = ½F\Delta x$



Work done on spring =
Average force x distance
= (0+F)/2 x Δx
= $½F\Delta x$

Calculate the elastic strain energy of the spring when stretched to 20mm by a force of 8N

Elastic Strain Energy



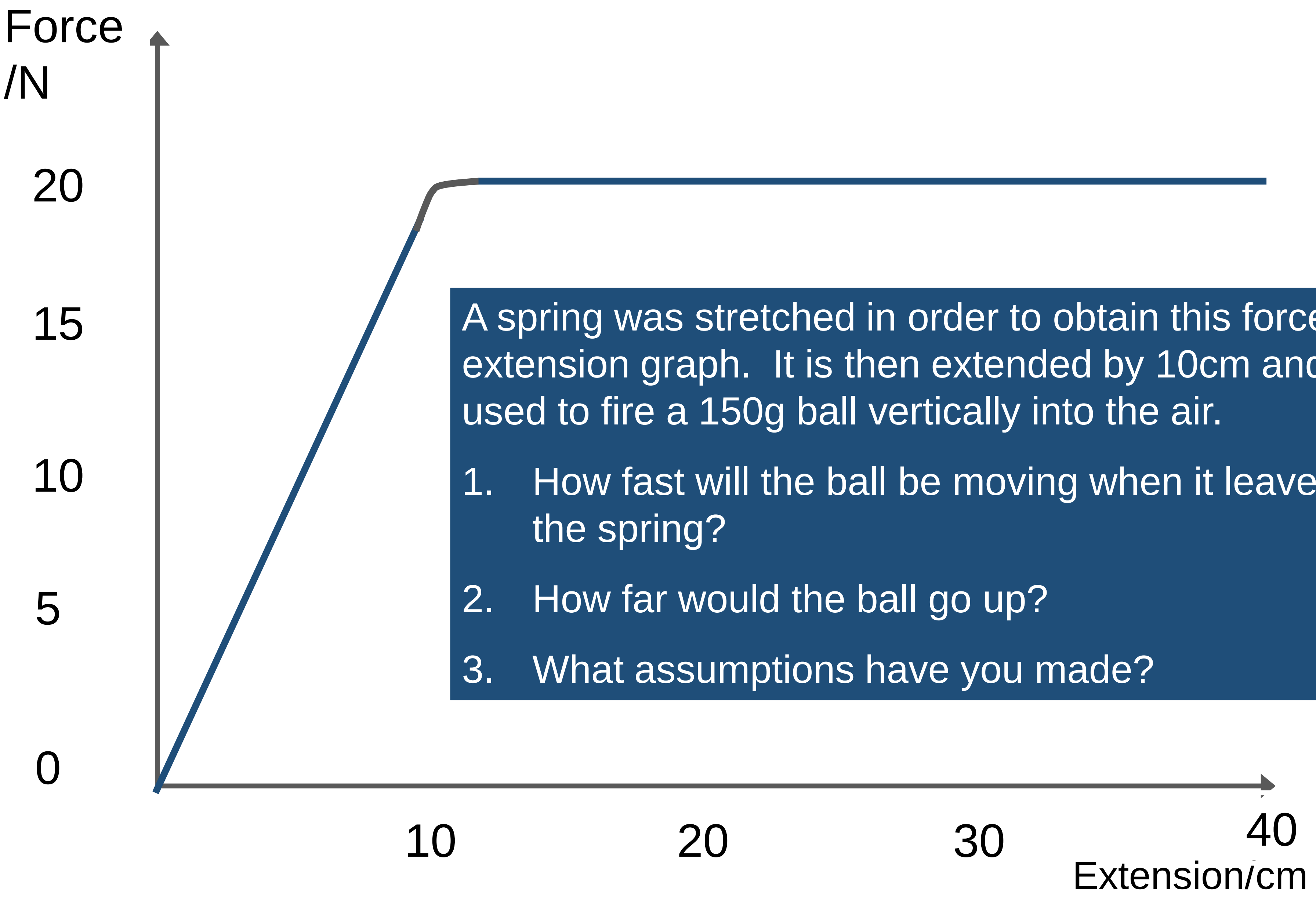
$E_{el} = ½F\Delta x$

$E_{el} = 0.5 \times 8 \times 2.0 \times 10^{-2}$

$=0.08$ J

= area under line

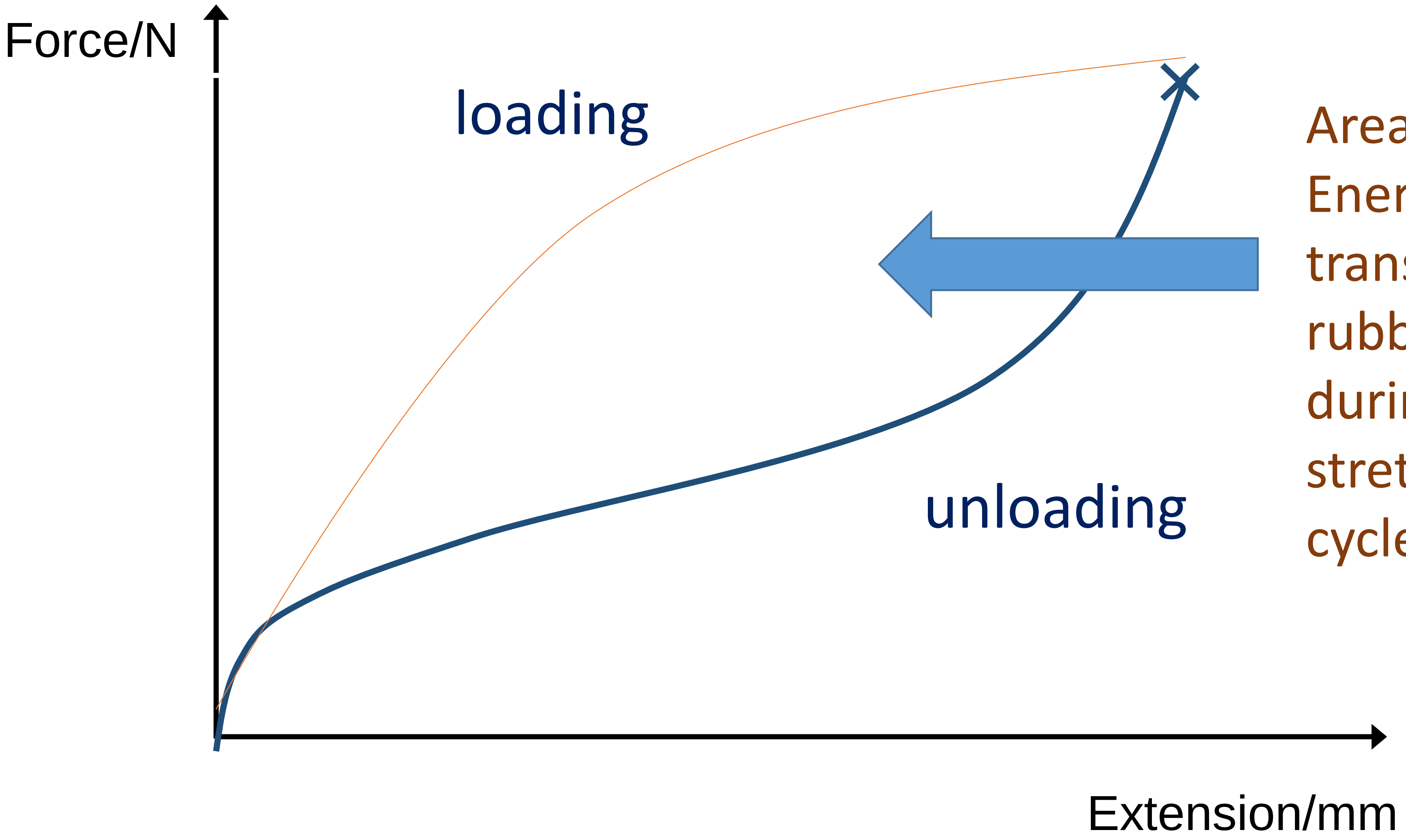
Question



A spring was stretched in order to obtain this force-extension graph. It is then extended by 10cm and used to fire a 150g ball vertically into the air.

1. How fast will the ball be moving when it leaves the spring?
2. How far would the ball go up?
3. What assumptions have you made?

Force-Extension Graph for rubber



Area enclosed = Energy transferred by rubber band during one stretch/unstretch cycle