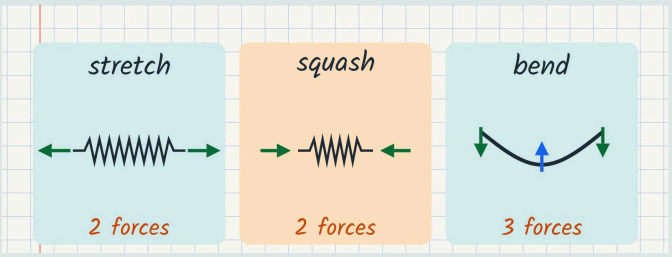
Stretching springs

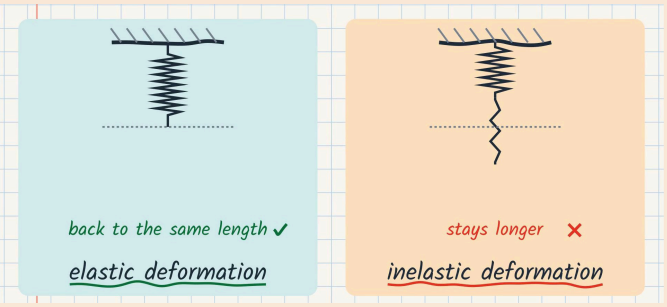
F = k e, the limit of proportionality, elastic energy

1 Changing shape



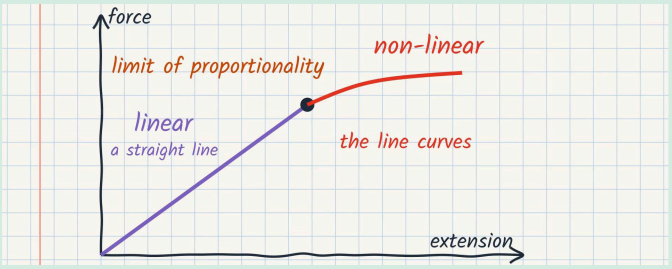
- You can **stretch**, **squash** or **bend** an object.
- To change the shape of an object that stays put you need **more than one force**. One force on its own just moves it.

2 Elastic or inelastic



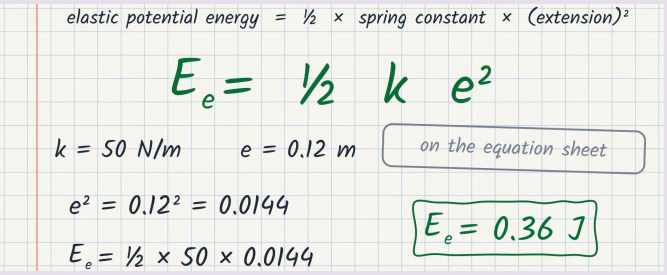
- **Elastic deformation**: the object goes back to its original shape when the force is removed.
- **Inelastic deformation**: it does not go back to its original shape when the force is removed.

3 F = k e



- **F = k e**: force (N) = spring constant (N/m) × extension (m). Extension goes up in equal steps, so it is **directly proportional** to the force.
- Only up to the **limit of proportionality**: before it the graph is **linear**, after it **non-linear**. The same equation works for compression.

4 Energy in a spring



- Work done stretching a spring is stored as **elastic potential energy**: equal to the work done if it is not deformed inelastically.
- $E_e = \frac{1}{2} k e^2$. For k = 50 N/m and e = 0.12 m: ½ × 50 × 0.0144 = **0.36 J**. Square only the extension.

$$F = k e$$

force = spring constant × extension

Exam tip

When you define inelastic deformation, finish the sentence: it does not return to its original shape when the force is removed. Convert the extension to metres first.

Check yourself

1. A spring has k = 40 N/m. What force stretches it by 0.2 m?
2. What is the point after which force and extension stop being proportional?

Answers: 1. F = k e = 40 × 0.2 = 8 N 2. the limit of proportionality