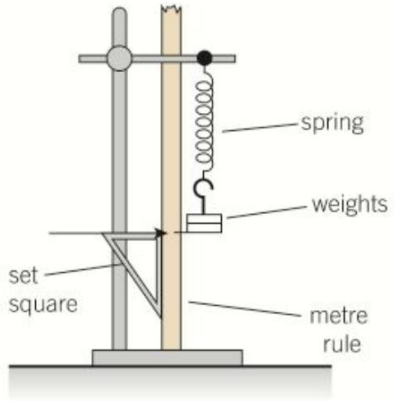
Starter questions – GCSE recap

Consider a mass on a spring

1. What is the relationship between the applied force F and extension ΔL?
2. What happens when you remove all the added masses?
3. What do we call this type of behaviour?
4. Can you think of other examples where this happens?
5. Is there a limit to this behaviour?
6. Sketch a graph of force against extension (loading a spring)



▲ **Figure 1** *Testing the extension of a spring*

Materials
L1: Springs & Hooke's Law

- State Hooke's Law and explain what 'elastic limit' means;
- To apply the Hooke's Law & recognise that the constant k is the stiffness or spring constant;
- Recognise that the energy stored is equal to the area under a force-extension graph

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Hooke's Law

Consider a mass on a spring

Tensile Force:

What is the relationship between the applied force F and extension ΔL?

This law applies to most springs, up to the limit of proportionality

Hooke's Law

$$F = k\,\Delta L$$

Limit of Proportionality:

1. A spring of natural length 250 mm is hung vertically. Its length increases to 350 mm when a weight of 12.0 N is attached to the other end. Calculate the spring constant *k* of the spring.

2. A vertical steel spring is fixed at its upper end and has an un-stretched length of 300 mm. Its length is increased to 385 mm when a 5 kg mass is attached. Calculate the spring constant.

Hooke's Law

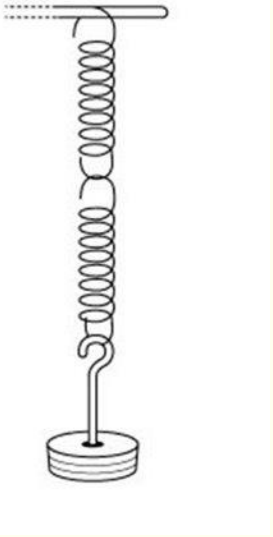
1. A spring stretches by 5 mm when a load of 20 N is applied to it. How much will the same spring extend when a load of 40 N is applied to it?

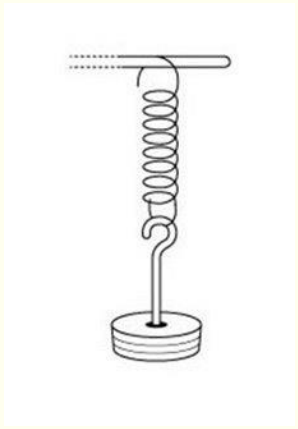
A. 7 mm
B. 10 mm
C. 12 mm
D. 15 mm

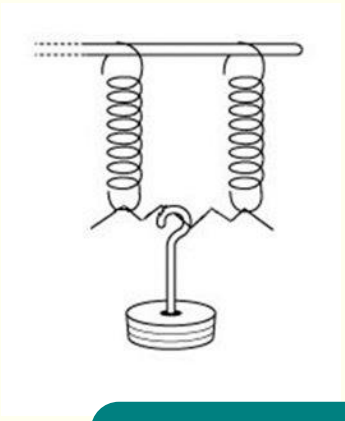
2. A spring stretches by 5 mm when a load of 20 N is applied to it. How big a load is needed for the same spring to stretch 15 mm?

A. 10 N
B. 30 N
C. 15 N
D. 60 N

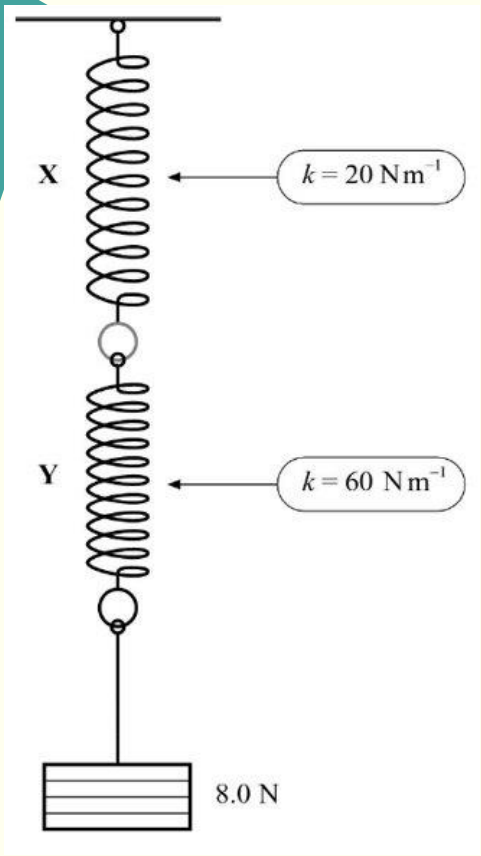
Springs in Series & Parallel







Does the arrangement of the springs matter?



Springs in Series

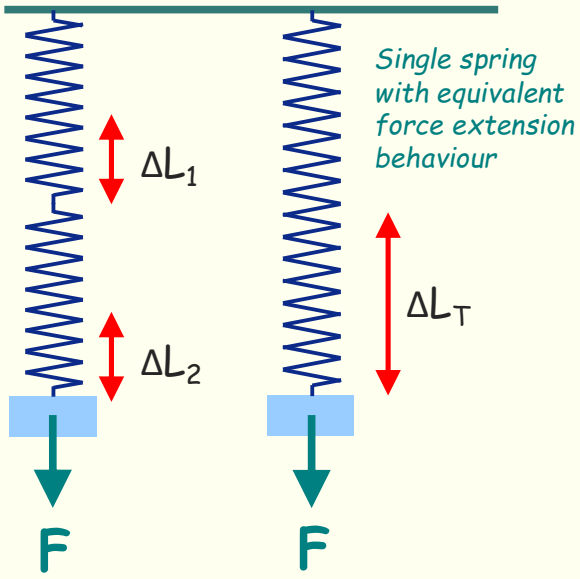
The diagram shows two springs X and Y connected in series and supporting a weight of 8.0 N. The spring constants are shown in the diagram.

a) Calculate the extension of each spring.

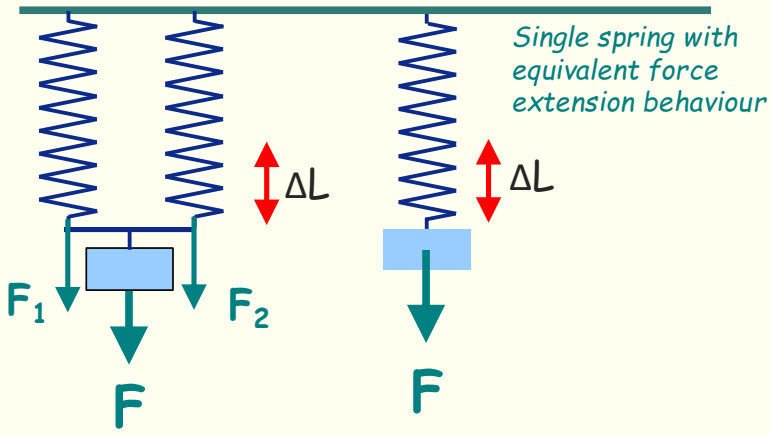
b) Determine the spring constant for the combination.

c) According to a student, the spring constant for the springs in series is the sum of the springs constants of the individual springs. Is the student correct?

Springs in Series



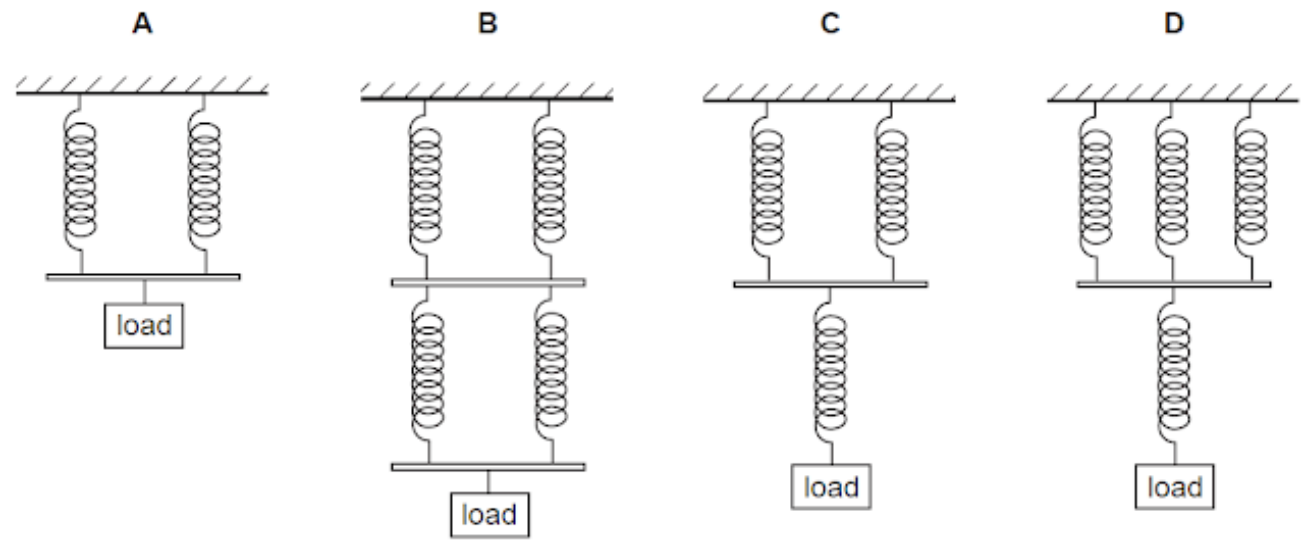
Springs in Parallel



Multiple Springs

Similar springs, each with the same spring constant are joined in four arrangements. The same load is applied to each.

Which arrangement gives the greatest extension?



Spring Behaviour

1. What happens when you remove all the added masses?
2. What do we call this type of behaviour?
3. Can you think of other examples where this happens?
4. Is there a limit to this behaviour?

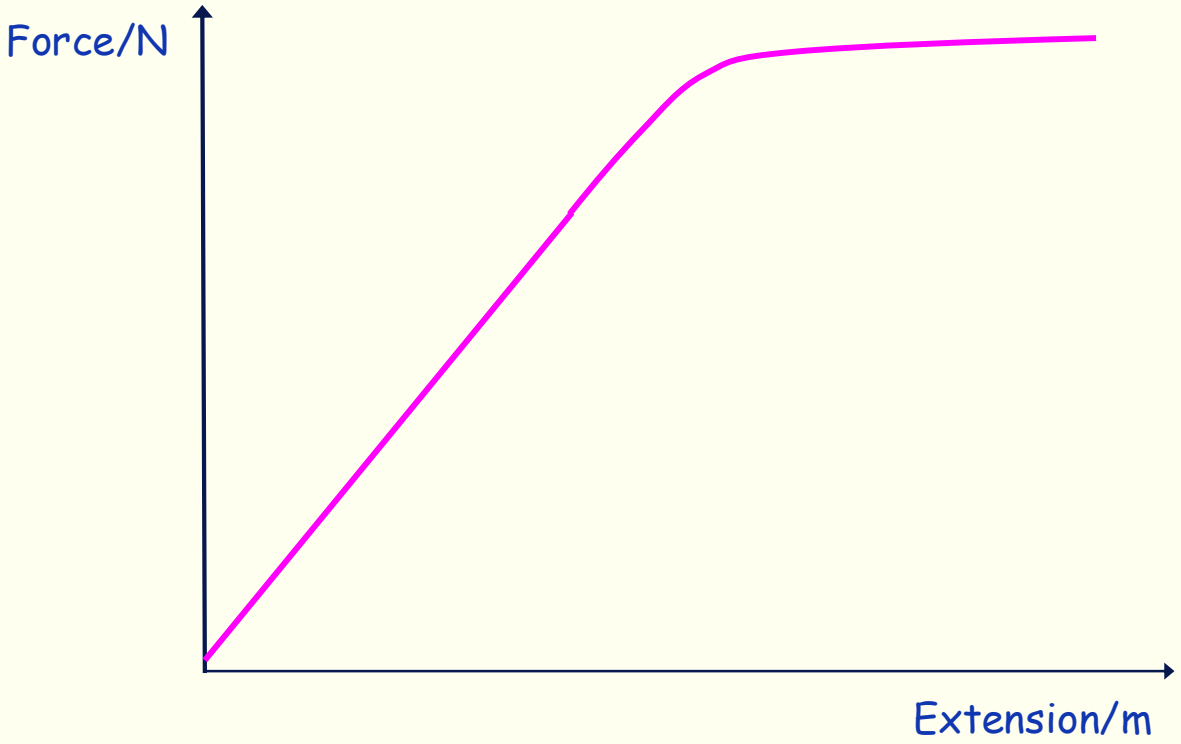
Key Terms

Elastic Deformation:

Elastic Limit:

Plastic Deformation:

Force-extension Graph for a Spring



Homework

- Q02 Calculation sheet - Understanding Hooke's Law

  Questions 1-4, question 5 (graph)

- Isaac Physics: B7 Springs

4 A student has two identical springs with spring constant 240 N m^{-1} and natural length 210 mm. The weight of the springs is negligible. Calculate the length of each of the springs when:

a they are joined vertically and stretched with a weight of 8.0 N (*2 marks*)

b they are joined in parallel and stretched with a weight of 8.0 N. (*2 marks*)

Materials
L2: Elastic strain energy

- Recognise that the energy stored is equal to the area under a force-extension graph

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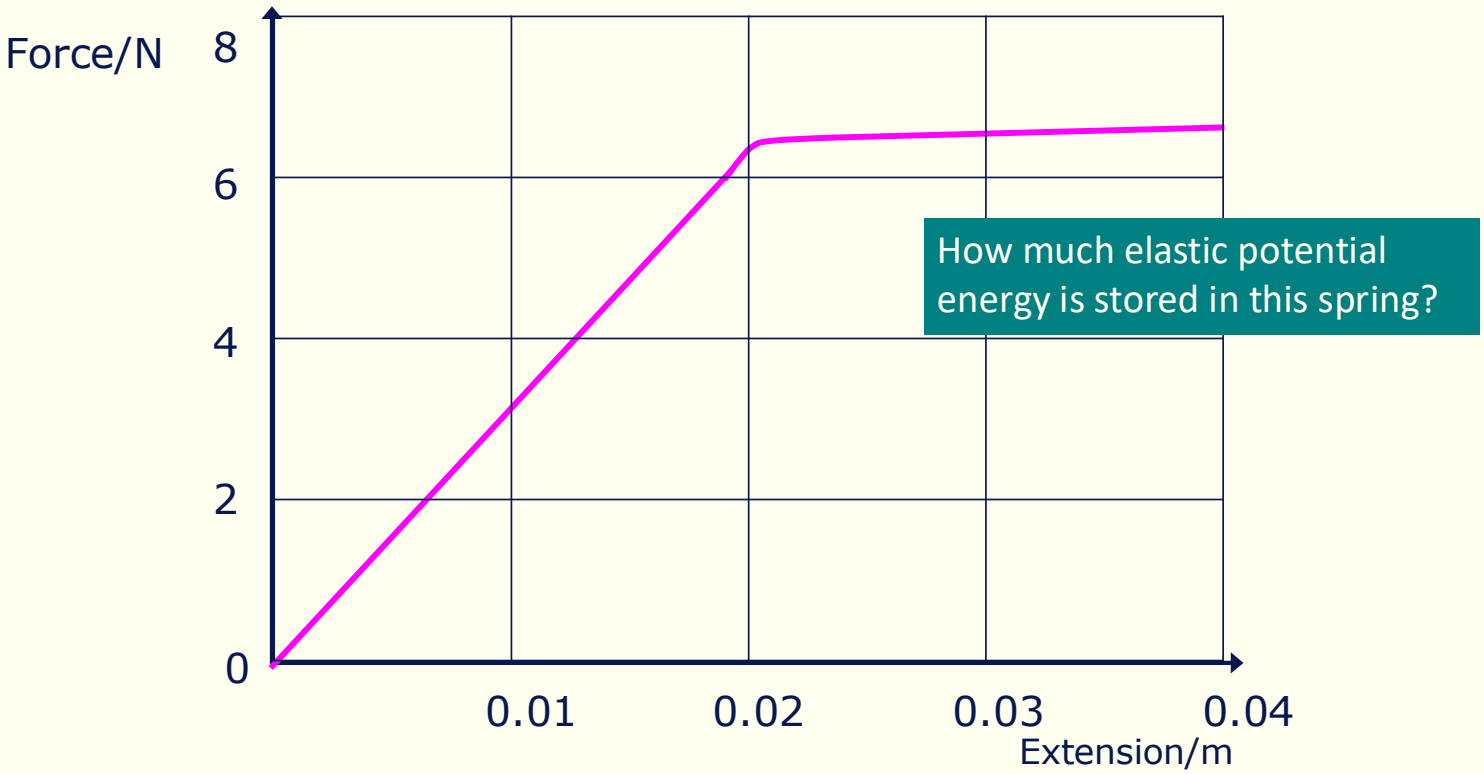
Elastic Strain Energy

Whenever you stretch a material, you are doing work. This is because the applied force moves through a distance as the material extends in the direction of the force.

Elastic strain energy:

Elastic Strain Energy



How much elastic potential energy is stored in this spring?

$g = 9.8\,\text{m s}^{-2}$

1 √x A steel spring has a spring constant of $25\,\text{N m}^{-1}$. Calculate:
   - **a** the extension of the spring when the tension in it is equal to 10 N
   - **b** the tension in the spring when it is extended by 0.50 m from its unstretched length.

2 √x Two identical steel springs of length 250 mm are suspended vertically side by side from a fixed point. A 40 N weight is attached to the ends of the two springs. The length of each spring is then 350 mm. Calculate:
   - **a** the tension in each spring
   - **b** the extension of each spring
   - **c** the spring constant of each spring.

3 √x Repeat **2a** and **b** for the two springs in series and vertical.

4 √x An object of mass 0.150 kg is attached to the lower end of a vertical spring of unstretched length 300 mm, which is fixed at its upper end. With the object at rest, the length of the spring becomes 420 mm as a result. Calculate:
   - **a** the spring constant
   - **b** the energy stored in the spring
   - **c** the weight that needs to be added to extend the spring to 600 mm.

Homework

- Q02 Calculation sheet – Elastic Energy

  Question 5

- Isaac Physics: B9 Energy, springs, and materials

Summary

Limit of Proportionality

Elastic Deformation

Plastic Deformation

Elastic Limit

- Hooke’s Law
- For springs in series
- For spring in parallel

- Elastic Strain Energy