

2.8 Spring Forces

Name: _____ Class: _____ Date: _____

Total: 15 marks

Objective

Build the skills to answer exam questions on **spring forces**.

You must be able to:

- use **Hooke's law** 胡克定律: the restoring force has magnitude $F = kx$
- explain the minus sign in $F = -kx$ (the force opposes the displacement)
- use the **spring constant** 劲度系数 k as force per unit stretch
- relate stiffness to k (larger k = stiffer)

1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Hooke's law

The size of the spring force grows with the stretch or compression:

$$F = kx.$$

A spring with $k = 200 \text{ N m}^{-1}$ stretched 0.1 m pulls back with $F = 200 \times 0.1 = 20 \text{ N}$.

■ The restoring direction

Written with direction, $F = -kx$: the minus sign means the force always points back toward the natural length, opposing the displacement.

■ The spring constant

k is the force needed per metre of stretch. A stiffer spring has a larger k . From data, $k = F/x$: if 15 N stretches a spring 0.05 m, then $k = 15/0.05 = 300 \text{ N m}^{-1}$.

2 Practice

Now apply the methods above.

2.1 A spring with $k = 100 \text{ N m}^{-1}$ is stretched 0.2 m. Find the force. [2]

2.2 State the meaning of the minus sign in $F = -kx$. [1]

2.3 A force of 12 N stretches a spring 0.03 m. Find k . [2]

2.4 Two springs stretch the same distance; spring A needs more force. Which has the larger k ? [1]

3 Exam-style questions

3.1 The magnitude of a spring's force is proportional to [1]

- **A** the mass on it
 - **B** its displacement from the natural length
 - **C** the square of the displacement
 - **D** time
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3.2 A spring force always points [1]

- **A** in the direction of the stretch
 - **B** back toward the natural length
 - **C** downward
 - **D** perpendicular to the spring
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3.3 A spring with $k = 500 \text{ N m}^{-1}$ is compressed 0.04 m.

(a) Find the size of the spring force. [2]

(b) State the direction of the force relative to the compression. [1]

3.4 A 2 kg mass hangs at rest from a spring, stretching it 0.1 m ($g = 10 \text{ m s}^{-2}$).

(a) State the spring force (it balances the weight). [1]

(b) Find the spring constant k . [2]

4 Go further

You are ready for more on this subtopic:

- work through the interactive **2.8 Spring Forces** lesson on the **Learn** page;
- read the **Force and Translational Dynamics** section of the AP Physics C: Mechanics handout on the **Know** page for the full explanation and worked diagrams.

Solutions

2.1 $F = kx = 100 \times 0.2 = 20 \text{ N}$.

2.2 The force opposes the displacement (points back toward the natural length).

2.3 $k = F/x = 12/0.03 = 400 \text{ N m}^{-1}$.

2.4 Spring A (more force for the same stretch means a larger k).

3.1 B — $F = kx$, proportional to displacement.

3.2 B —the restoring force points back toward the natural length.

3.3 (a) $F = kx = 500 \times 0.04 = 20 \text{ N}$. (b) Opposite to the compression (pushing outward).

3.4 (a) $F = mg = 20 \text{ N}$. (b) $k = F/x = 20/0.1 = 200 \text{ N m}^{-1}$.