

## 2.8 Spring Forces

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

**Total: 11 marks**

**KEY WORDS** spring constant 彈簧常數 • slope 斜率 • hooke's law 胡克定律 • restoring force 回復力  
• force 力

### Objective

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

**You must be able to:**

- state **Hooke's law** 胡克定律,  $F_s = -k \Delta x$
- define the **spring constant** 彈簧常數  $k$  as a measure of stiffness
- explain that the spring force is a **restoring force** 回復力 directed opposite to the displacement
- find  $k$  from the **slope** 斜率 of a force-versus-displacement graph

### 1 Worked examples

Study these first. Each one shows the method for a question type used later.

#### ■ Hooke's law

$F_s = -k \Delta x$ : the restoring force is proportional to the stretch or compression  $\Delta x$  from the natural length, and points **back toward equilibrium**. The magnitude is  $|F_s| = k |\Delta x|$ .

#### ■ Finding the spring constant

A force of 6.0 N stretches a spring by 0.020 m:  $k = \frac{F}{\Delta x} = \frac{6.0}{0.020} = 300 \text{ N m}^{-1}$ .

#### ■ Reading a force-extension graph

For a spring that obeys Hooke's law, force vs extension is a straight line through the origin; its **slope is  $k$** . A steeper line means a stiffer spring.

### 2 Practice

**2.1** A spring is stretched 0.10 m by a force of 25 N. Find its spring constant. [2]

**2.2** State the direction of the spring force when a spring is **compressed**. [1]

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**2.3** A spring has  $k = 400 \text{ N m}^{-1}$ . Find the force needed to stretch it 0.05 m. [1]

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**2.4** Two springs have force-extension graphs; spring P has a steeper line than spring Q. State which is stiffer. [1]

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### 3 Exam-style questions

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**3.1** The negative sign in  $F_s = -k \Delta x$  shows that the spring force [1]

- **A** is always downward
  - **B** opposes the displacement from equilibrium
  - **C** decreases with time
  - **D** is a contact force
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**3.2** A force of 12 N stretches a spring 0.03 m. Its spring constant is [1]

- **A**  $0.36 \text{ N m}^{-1}$
  - **B**  $4.0 \text{ N m}^{-1}$
  - **C**  $36 \text{ N m}^{-1}$
  - **D**  $400 \text{ N m}^{-1}$
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**3.3** A spring hangs vertically. Adding a 2.0 kg mass stretches it 0.08 m (take  $g = 10 \text{ m s}^{-2}$ ).

(a) Find the spring constant. [2]

(b) Find the extension produced by a 5.0 kg mass. [2]

## Solutions

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**2.1**  $k = \frac{F}{\Delta x} = \frac{25}{0.10} = 250 \text{ N m}^{-1}.$

**2.2** outward, away from the compression — back toward the natural length.

**2.3**  $F = k \Delta x = 400 \times 0.05 = 20 \text{ N}.$

**2.4** spring P (steeper slope = larger  $k$ ).

**3.1** B.

**3.2** D —  $k = 12/0.03 = 400 \text{ N m}^{-1}.$

**3.3** (a)  $F = mg = 20 \text{ N}; k = \frac{20}{0.08} = 250 \text{ N m}^{-1}.$  (b)  $F = 50 \text{ N}; \Delta x = \frac{50}{250} = 0.20 \text{ m}.$