Exercise walk-through

Spring Forces ▪ 2.8

eXercise

You must be able to

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

Method — Hooke's law

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

Method — Finding the spring constant

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

Method — 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.

Practice 2.1 ▪ 2 marks

A spring is stretched 0.10 m by a force of 25 N. Find its spring constant.

Solution 2.1

Method: Finding the spring constant

Worked steps

$$k = \frac{F}{\Delta x} = \frac{25}{0.10} = 250 \text{ N m}^{-1}$$ M1 A1.

Practice 2.2 ▪ 1 mark

State the direction of the spring force when a spring is **compressed**.

Solution 2.2

Worked steps

outward, away from the compression — back toward the natural length B1.

Practice 2.3 ▪ 1 mark

A spring has $k = 400$ N m^{-1}. Find the force needed to stretch it 0.05 m.

Solution 2.3

Method: Finding the spring constant

Worked steps

$F = k\Delta x = 400 \times 0.05 = 20$ N B1.

Practice 2.4 ▪ 1 mark

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

Solution 2.4

Method: Reading a force-extension graph

Worked steps

spring P (steeper slope = larger k) B1.

Exam-style 3.1 ▪ 1 mark

The negative sign in $F_s = -k\Delta x$ shows that the spring force

A is always downward

B opposes the displacement from equilibrium

C decreases with time

D is a contact force

Solution 3.1

Method: Finding the spring constant

A is always downward

B opposes the displacement from equilibrium ✓

C decreases with time

D is a contact force

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

A force of 12 N stretches a spring 0.03 m. Its spring constant is

A 0.36 N m^{-1}

B 4.0 N m^{-1}

C 36 N m^{-1}

D 400 N m^{-1}

Solution 3.2

Method: Finding the spring constant

A 0.36 N m^{-1}

B 4.0 N m^{-1}

C 36 N m^{-1}

D 400 N m^{-1} ✓

Worked steps

D — $k = 12/0.03 = 400$ N m^{-1}.

Exam-style 3.3 ▪ 2 marks

A spring hangs vertically. Adding a 2.0 kg mass stretches it 0.08 m (take $g = 10$ m s^{-2}).
(a) Find the spring constant.
(b) Find the extension produced by a 5.0 kg mass.

Solution 3.3

Method: Finding the spring constant

Worked steps

(a) $F = mg = 20$ N; $k = \dfrac{20}{0.08} = 250$ N m^{-1} M1 A1. (b) $F = 50$ N; $\Delta x = \dfrac{50}{250} = 0.20$ m M1 A1.