Exercise walk-through

Spring Forces ▪ 2.8

eXercise

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)

Method — Hooke's law

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

$$F = kx.$$

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

Method — The restoring direction

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

Method — 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 $k = 15/0.05 = 300$ N m^{-1}.

Practice 2.1 ▪ 2 marks

A spring with $k = 100$ N m^{-1} is stretched 0.2 m. Find the force.

Solution 2.1

Method: Hooke's law

Worked steps

$F = kx = 100 \times 0.2 = 20$ N M1 A1.

Practice 2.2 ▪ 1 mark

State the meaning of the minus sign in $F = -kx$.

Solution 2.2

Method: The restoring direction

Worked steps

The force opposes the displacement (points back toward the natural length) B1.

Practice 2.3 ▪ 2 marks

A force of 12 N stretches a spring 0.03 m. Find k.

Solution 2.3

Method: The spring constant

Worked steps

$k = F/x = 12/0.03 = 400$ N m^{-1} M1 A1.

Practice 2.4 ▪ 1 mark

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

Solution 2.4

Method: The spring constant

Worked steps

Spring A (more force for the same stretch means a larger k) B1.

Exam-style 3.1 ▪ 1 mark

The magnitude of a spring's force is proportional to

A the mass on it

B its displacement from the natural length

C the square of the displacement

D time

Solution 3.1

A the mass on it

B its displacement from the natural length ✓

C the square of the displacement

D time

Worked steps

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

Exam-style 3.2 ▪ 1 mark

A spring force always points

A in the direction of the stretch

B back toward the natural length

C downward

D perpendicular to the spring

Solution 3.2

Method: The restoring direction

A in the direction of the stretch

B back toward the natural length ✓

C downward

D perpendicular to the spring

Worked steps

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

Exam-style 3.3 ▪ 2 marks

A spring with $k = 500$ N m^{-1} is compressed 0.04 m.
(a) Find the size of the spring force.
(b) State the direction of the force relative to the compression.

Solution 3.3

Method: Hooke's law

Worked steps

(a) $F = kx = 500 \times 0.04 = 20$ N M1 A1. (b) Opposite to the compression (pushing outward) B1.

Exam-style 3.4 ▪ 1 mark

A 2 kg mass hangs at rest from a spring, stretching it 0.1 m ($g = 10$ m s^{-2}).
(a) State the spring force (it balances the weight).
(b) Find the spring constant k.

Solution 3.4

Method: The spring constant

Worked steps

(a) $F = mg = 20$ N B1. (b) $k = F/x = 20/0.1 = 200$ N m^{-1} M1 A1.