AP PHYSICS 1 • EXERCISE SHEET

2.8 Spring Forces

Name: _____ Class: _____ Date: _____ **Total: 11 marks**

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** 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

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 Δx 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: $k = \dfrac{F}{\Delta x} = \dfrac{6.0}{0.020} = 300\ \text{N m}^{-1}$.

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]

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

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

3 Exam-style questions

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

3.2 A force of 12 N stretches a spring 0.03 m. Its spring constant is [1]

- **A** 0.36 N m^{-1}
- **B** 4.0 N m^{-1}
- **C** 36 N m^{-1}
- **D** 400 N m^{-1}

3.3 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. [2]

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

4 Go further

- work through the **2.8 Spring Forces** lesson on the **Learn** page;
- read the **Force and Translational Dynamics** section of the AP Physics 1 handout on the **Know** page.

Solutions

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

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

2.3 $F = k\,\Delta x = 400 \times 0.05 = 20$ N.

2.4 spring P (steeper slope = larger k).

3.1 **B**.

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

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