Exercise walk-through

Defining Simple Harmonic Motion (SHM) ▪ 7.1

eXercise

You must be able to

- define **simple harmonic motion** 简谐运动 as motion where the restoring force is proportional to the displacement
- identify the condition $F = -kx$ that produces SHM
- give examples of SHM, such as a mass on a spring and a small-angle pendulum

Method — The condition for SHM

The **restoring force** 回復力 is proportional to the displacement and points back toward equilibrium: $F = -kx$. The negative sign is what makes the motion oscillate.

Method — Examples

A mass on a spring, and a pendulum swinging through a **small** angle, both obey $F = -kx$ (approximately, for the pendulum).

Method — Not SHM

A ball bouncing off the floor is periodic but **not** SHM — its force is not proportional to displacement.

Practice 2.1 ▪ 1 mark

State the condition on the restoring force for simple harmonic motion.

Solution 2.1

Method: The condition for SHM

Worked steps

it must be proportional to the displacement and directed back toward equilibrium ($F = -kx$) B1.

Practice 2.2 ▪ 2 marks

Give two examples of systems that perform SHM.

Solution 2.2

Worked steps

a mass on a spring; a small-angle pendulum B1 B1.

Practice 2.3 ▪ 1 mark

A spring obeys $F = -kx$. State the direction of the force when the mass is displaced to the right of equilibrium.

Solution 2.3

Worked steps

to the left, back toward equilibrium B1.

Exam-style 3.1 ▪ 1 mark

In simple harmonic motion, the restoring force is

A constant

B proportional to the displacement

C proportional to the speed

D always zero

Solution 3.1

Method: The condition for SHM

A constant

B proportional to the displacement ✓

C proportional to the speed

D always zero

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

Which of these is an example of SHM?

A a ball rolling down a hill

B a mass oscillating on a spring

C a car braking to a stop

D a satellite in a circular orbit

Solution 3.2

A a ball rolling down a hill

B a mass oscillating on a spring ✓

C a car braking to a stop

D a satellite in a circular orbit

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 0.50 kg mass on a spring of constant $k = 200$ N m^{-1} is pulled 0.10 m from equilibrium.

(a) Find the size of the restoring force.

(b) State the direction of this force.

Solution 3.3

Method: The condition for SHM

Worked steps

(a) $F = kx = 200 \times 0.10 = 20$ N M1 A1. (b) toward equilibrium (to the left) B1.