Simple Harmonic Motion

Physics

The defining condition, and the equations that follow.

In SHM, acceleration is proportional to displacement and always directed toward the equilibrium position.

$$a = -\omega^2 x \cdot x = A\cos(\omega t) \cdot T = 2\pi\sqrt{(m/k)}$$

Mass on a spring

$T = 2\pi\sqrt{(m/k)}$

Independent of amplitude.

Simple pendulum

$T = 2\pi\sqrt{(L/g)}$

Small angles only.

Maximum speed

$v = \omega A$

At the equilibrium position.

THE COMMON MISTAKE

× Assuming a pendulum is SHM at any angle

✓ Only for small angles

The restoring force is mg sin θ, which is proportional to θ only when sin θ ≈ θ — below roughly 10°.

The minus sign in $a = -\omega^2 x$ is the whole physics: the acceleration always opposes the displacement.