

# Physics Society - Simple Harmonic Motion

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November 2025

## 1 Introduction

Last week, we did a brief introduction to Quantum Mechanics. Today, we are going to be discussing a classical phenomenon that crops up in all areas of physics, and is essential for further progress into the quantum realm. This concept is **simple harmonic motion**.

Put rather simply, simple harmonic motion occurs wherever the acceleration of an object is negatively proportional to the position of the particle. In other words:

$$a = -\omega^2 x$$

Substituting  $a = \frac{d^2x}{dt^2}$ ,

$$\frac{d^2x}{dt^2} = -\omega^2 x$$

The general solution for this **second-order differential equation** is:

$$x = A \sin(\omega t + \phi) + B \cos(\omega t + \phi)$$

The parameters  $A, B$  and  $\phi$  are varied to fit the initial conditions (often, one of either A or B will be 0). The sum results in a sinusoidal curve.

$\omega$  is a lowercase Greek letter, omega. It represents the **angular frequency** of the oscillation. It relates to the time period and frequency of the oscillation by:

$$T = \frac{2\pi}{\omega}$$
$$\omega = 2\pi f$$

Verify that the solution of the SHM equation satisfies  $a = -\omega^2 x$

**Question 1** Prove that a pendulum follows simple harmonic motion, use a small angle approximation.

**Question 2** An object is on a platform oscillating up and down following SHM. What is the minimum angular frequency it must oscillate with for the object to lose contact with the platform?

**Question 3** Find the total energy of an SHM system in terms of the parameters.

## 2 Additional problems and reading

**Question 4** Prove that the motion of an object falling through a hole in the centre of the Earth follows simple harmonic motion. Find its time period.

How would simple harmonic motion look like in two dimensions?

How would simple harmonic motion look like in three dimensions?

Read about harmonic oscillators in quantum mechanics.

As per usual, check out some problems on Isaac Science about SHM, there are lots of interesting ones! Check out the Feynman Lectures Volume 1 Chapter 21: [https://www.feynmanlectures.caltech.edu/I\\_21.html](https://www.feynmanlectures.caltech.edu/I_21.html)

Thank you all for coming!