KECUDO

PREMIUM EDITION III

PHYSICS ESSENTIALS

Class 3

Waves & Sound

From a bouncing spring to a guitar string — oscillations, waves, the speed of sound, decibels, music and the Doppler effect, with worked examples and real data.



2026 EDITION · SCIENCE SERIES

13 chapters · 79 scored questions · 26 practice problems

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Every chapter ends with a Quick Check page.

● ○ ○ FOUNDATION PART I · FOUNDATIONS

Chapter 1

Oscillations

An **oscillation** is any motion that repeats: a swing, a vibrating guitar string, a mass bouncing on a spring. Waves are built from oscillations, so we start here.

TERM	MEANING	UNIT
Amplitude A	biggest distance from the middle (equilibrium)	m
Period T	time for one full cycle	s
Frequency f	cycles per second	hertz (Hz)
Angular frequency ω	2π·f	rad/s

PERIOD AND FREQUENCY

$$f = 1 \div T \quad \cdot \quad \omega = 2\pi f$$

When the restoring force grows in step with displacement (F = −kx, Hooke's law from Class 2), the motion is **simple harmonic motion** (SHM): a smooth sine wave in time.

IN THIS CHAPTER

- Amplitude, period, frequency
- Simple harmonic motion
- Energy in an oscillating spring

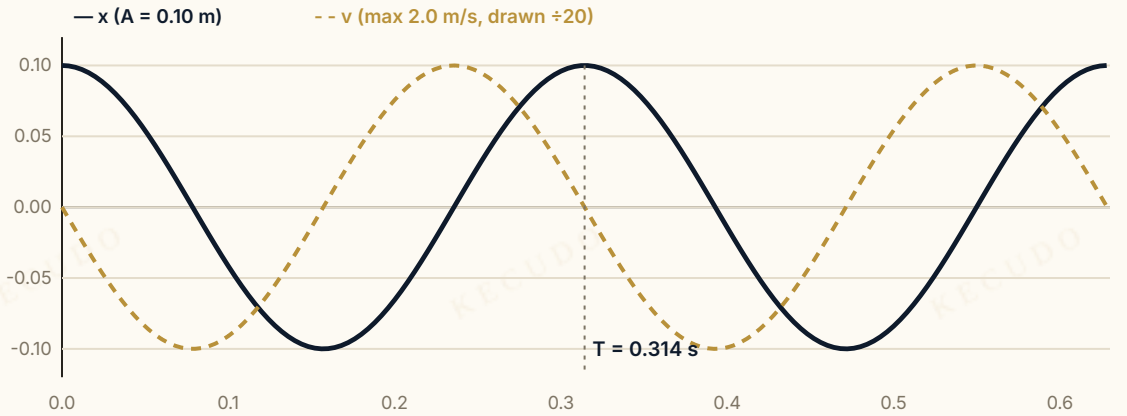
COMMON PITFALL

Mixing up period (seconds per cycle) and frequency (cycles per second).

Kecudo Toy Co. — the Class 2 spring returns

A 2 kg mass hangs on the k = 800 N/m spring, pulled 0.10 m and released. ω = √(k ÷ m) = √(800 ÷ 2) = **20 rad/s**.

FIG 1.1 Position (navy) and velocity (gold, dashed) over two periods



QUANTITY	CALCULATION	RESULT
Period	2π ÷ 20	0.314 s
Frequency	1 ÷ 0.314	3.18 Hz
Maximum speed (at the middle)	A·ω = 0.10 × 20	2.0 m/s
Energy: $\frac{1}{2}kA^2 = \frac{1}{2}mv^2_{max}$	**$\frac{1}{2} \times 800 \times 0.1^2 = \frac{1}{2} \times 2 \times 2^2$**	**4.0 J ✓**

The 4 J matches the spring energy from Class 2 — energy sloshes between elastic PE (at the ends) and KE (in the middle).

FOUNDATION PART I · FOUNDATIONS

Chapter 2

Springs & Pendulums

Two simple oscillators keep time in clocks, car suspensions and playground swings. Their periods follow simple rules.

PERIODS

Spring: $T = 2\pi\sqrt{(m \div k)}$ · Pendulum: $T = 2\pi\sqrt{(L \div g)}$

Spring: a heavier mass swings more slowly; a stiffer spring speeds it up. **Pendulum** (small swings): only the length and gravity matter — not the mass, not the amplitude. Galileo noticed this in the 1580s.

CHANGE	SPRING PERIOD	PENDULUM PERIOD
×4 mass	×2	no change
×4 stiffness k	÷2	—
×4 length	—	×2
Weaker gravity	no change	longer

IN THIS CHAPTER

- Spring period 2π√(m/k)
- Pendulum period 2π√(L/g)
- Pendulums as gravity meters (NASA data)

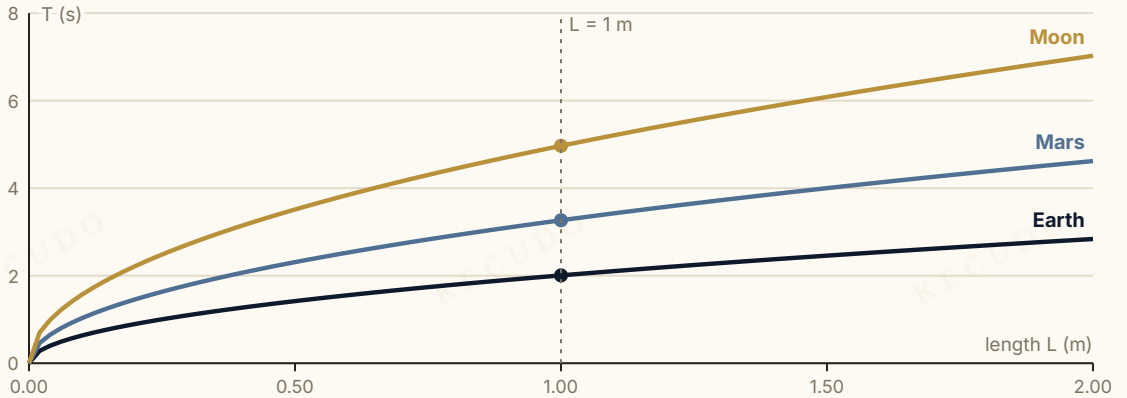
COMMON PITFALL

Thinking a heavier pendulum bob swings more slowly.

Real data: a 1 m pendulum on other worlds

A pendulum is a gravity meter. Using NASA's surface-gravity values, a 1 m pendulum ticks at very different rates:

FIG 2.1 Period of a pendulum (s) vs length (m) on Earth, Mars and the Moon



Source: NASA Planetary Fact Sheet – Metric (NSSDCA, Goddard Space Flight Center).

BODY	G (M/S²)	PERIOD OF A 1 M PENDULUM
Jupiter	23.1	1.31 s
Earth	9.8	2.01 s
Mars	3.7	3.27 s
Moon	1.6	4.97 s

On Earth, a 0.248 m pendulum has a 1.00 s period — handy for a home-made clock.

Self-Assessment · Part A

Basics

40 questions in 5 parts. Each answer locks once chosen and shows a one-line explanation. Your score updates in the top bar; your rating is on the Results page.

A1 Frequency is measured in...

- **A** seconds
- **B** metres
- **C** hertz
- **D** decibels

A2 Sound is a...

- **A** particle stream
- **B** transverse electromagnetic wave
- **C** transverse mechanical wave only
- **D** longitudinal mechanical wave

A3 The distance from one crest to the next is the...

- **A** amplitude
- **B** wavelength
- **C** frequency
- **D** period

A4 Loudness mainly depends on a sound wave's...

- **A** frequency
- **B** wavelength
- **C** amplitude
- **D** speed



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{SERIES}

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