

Springs, pendulums and simple harmonic motion

AP Physics 1 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train the skills of AP Physics 1 unit 7: finding periods of springs and pendulums, reading displacement and energy graphs, and using energy to find speeds. The early problems are one-step recall and calculation; the last five are multi-step or AP-style free-response tasks.

Use $g = 9.81 \text{ N/kg}$ and show every step. Several problems ask you to translate between words, equations and graphs, to design a short experiment, or to write a paragraph argument supported by physics.

Level: AP Physics 1 (algebra-based) · **Curriculum:** AP P1 Unit 7

Problem 1 Which motions are SHM? (easy)

Aarav in Pune lists four motions: (A) a block on a horizontal spring pulled aside and released, (B) a ball dropped onto a floor and bouncing, (C) a pendulum swinging through 5° , (D) a cyclist going round a circular track at constant speed.

1. Identify which motions are simple harmonic, or close to it.
2. State the condition on the net force that you used.

Problem 2 Metronome timing (easy)

The arm of Kofi's metronome in Accra completes 72 full cycles in one minute.

1. Calculate the frequency.
2. Calculate the period.
3. Calculate how many complete cycles occur in 5.0 minutes.

Problem 3 Spring force (easy)

A spring of constant 120 N/m in a pressure-cooker valve in Mumbai is stretched by 0.15 m .

1. Calculate the magnitude of the spring force.
2. State the direction of the force relative to the displacement.
3. Calculate the force when the spring is instead compressed by 0.050 m .

Problem 4 Period of a spring (easy)

A 0.60 kg cart on a low-friction track is joined to a spring with $k = 150 \text{ N/m}$ and set

oscillating.

1. Calculate the period.
2. Calculate the frequency.
3. State the new period if the amplitude is doubled.

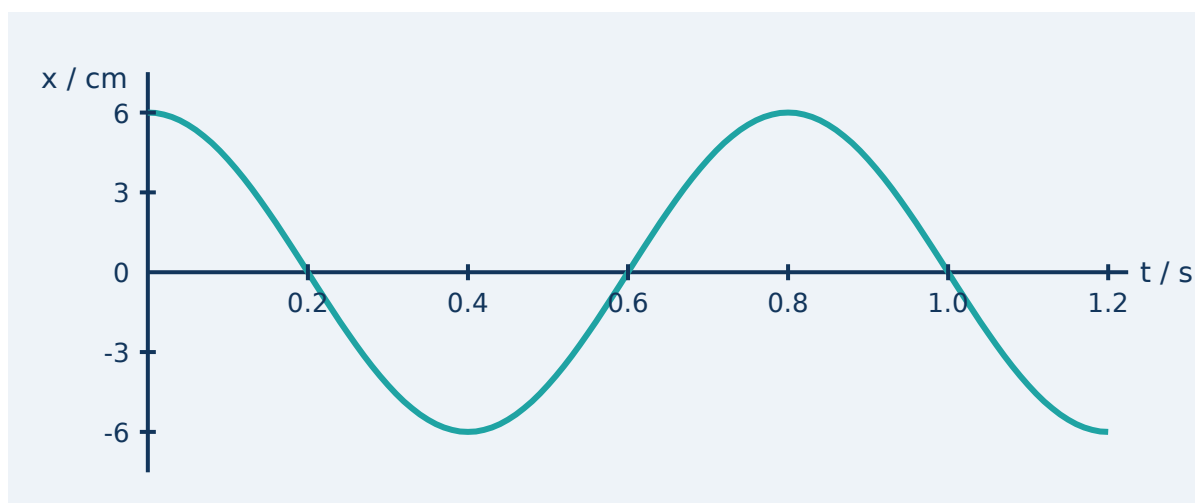
Problem 5 Period of a pendulum (easy)

Chiamaka in Lagos hangs a 50 g steel bob on a thread so that the length from pivot to the centre of the bob is 0.640 m. She releases it from 6° .

1. Calculate the period.
2. State the period if a 100 g bob is used instead.

Problem 6 Reading an x-t graph (easy)

Mei in Singapore records the motion of a mass on a spring.



Displacement of a mass on a spring recorded by a motion sensor.

1. State the amplitude.
2. State the period and the frequency.
3. State two times between 0 and 0.80 s at which the speed is zero, and one time at which it is greatest.

Problem 7 Spring constant from stretch (medium)

A 350 g mass hangs at rest from a spring and stretches it by 8.4 cm. Use $g = 9.81 \text{ N/kg}$.

1. Convert the data to SI units.
2. Calculate the spring constant.
3. Calculate the period when the mass is pulled down a little and released.

Problem 8 Energy of a glider (medium)

An air-track glider of mass 0.80 kg is attached to a spring with $k = 150 \text{ N/m}$ and released from rest at $A = 0.20 \text{ m}$ in Bilal's lab in Lahore.

1. Calculate the total mechanical energy.
2. Calculate the maximum speed.
3. Calculate the speed when the glider is 0.10 m from the centre.

Problem 9 Scaling the period (medium)

A particular mass-spring system has a period of 1.2 s. Predict the new period in each case, giving a reason.

1. The mass is quadrupled.
2. The amplitude is doubled.
3. The spring is replaced by one four times as stiff.
4. The system is taken to the Moon, where g is smaller, and set up horizontally on a smooth table.

Problem 10 Finding g with a pendulum (medium)

Diego in Texas times 15 complete swings of a pendulum of length 1.20 m (pivot to centre of bob) and records 33.0 s.

1. Calculate the period.
2. Rearrange $T = 2\pi\sqrt{L/g}$ to make g the subject.
3. Calculate g .
4. Calculate the percentage difference from 9.81 m/s^2 .

Problem 11 Greatest acceleration (medium)

A decorative 0.25 kg ornament on a spring ($k = 64 \text{ N/m}$) sits on a minibus dashboard and oscillates horizontally with amplitude 0.050 m.

1. Calculate the greatest force on the ornament.
2. Calculate the greatest acceleration.
3. State the direction of the acceleration at $x = +A$.

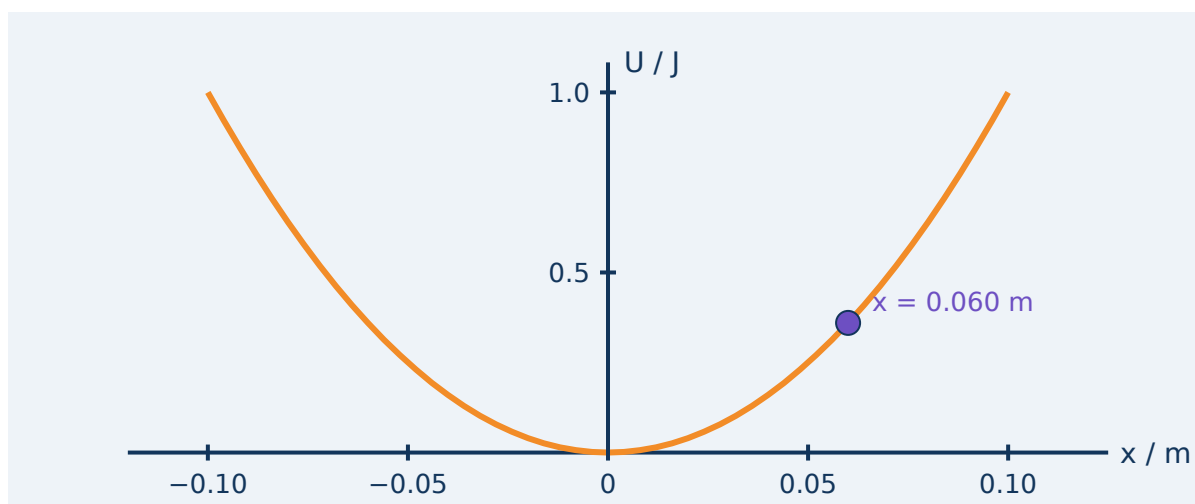
Problem 12 A vertical spring (medium)

A 0.40 kg mass hangs from a spring with $k = 32 \text{ N/m}$. It is pulled down 0.050 m from equilibrium and released. Use $g = 9.81 \text{ N/kg}$.

1. Calculate how far the spring stretches at equilibrium.
2. Calculate the period.
3. Calculate the net force at the lowest point, and the spring force there.

Problem 13 Reading an energy graph (medium)

The graph shows the spring energy of a 0.50 kg oscillator.

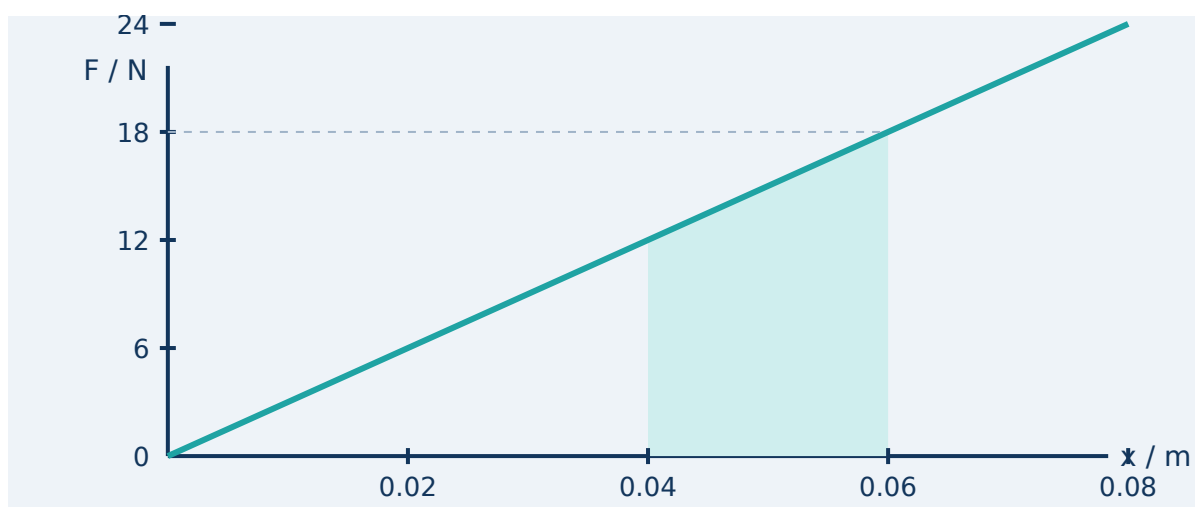


Potential energy of a spring oscillator against displacement.

1. State the total energy of the oscillator.
2. Calculate the spring constant.
3. Use the marked point to find the kinetic energy at $x = 0.060$ m.
4. Calculate the speed at that point.

Problem 14 Force and work from a graph (medium)

Wanjiru in Nairobi tests a spring from a gate latch.



Force against extension for a spring from a gate latch. The shaded strip lies between $x = 0.040$ m and $x = 0.060$ m.

1. Calculate the spring constant from the gradient.
2. Calculate the elastic energy stored at $x = 0.060$ m.
3. Calculate the extra energy stored when the extension grows from 0.040 m to 0.060 m.

Problem 15 Pendulum length for a target period (medium)

A designer in Leeds wants a decorative pendulum to take exactly 2.00 s for one full swing.

1. Calculate the required length from pivot to centre of bob.
2. State the length needed for a period of 1.00 s.

3. Explain why the second answer is not half of the first.

Problem 16 Translating between graphs (hard)

A 0.20 kg mass on a horizontal spring is released from rest at $x = +0.050$ m and completes one cycle every 0.40 s.

1. Calculate the spring constant.
2. Calculate the greatest speed and the greatest acceleration.
3. Describe, with key values, the shape of the v-t graph and the a-t graph for the first 0.40 s.

Problem 17 Designing a timing experiment (hard)

Aarav wants to test whether the period of a pendulum depends on its amplitude. His stopwatch reaction time is about 0.2 s and one swing takes about 1.5 s.

1. Calculate the percentage uncertainty if he times a single swing.
2. Calculate the percentage uncertainty if he times 20 swings.
3. Outline a procedure that tests amplitude, naming the independent variable, the dependent variable and two controlled variables.

Problem 18 Argue about a vertical spring (hard)

Two students disagree about a 0.50 kg mass on a spring with $k = 50$ N/m. Student 1 says that hanging the spring vertically shortens the period because gravity speeds the mass up. Student 2 says the period is the same as for a horizontal arrangement.

1. Calculate the period for the horizontal case.
2. Calculate the equilibrium shift in the vertical case.
3. Write a short paragraph that supports the correct claim with evidence from forces.

Problem 19 Clay dropped on a block (hard)

A 0.90 kg block oscillates on a smooth horizontal table on a spring with $k = 100$ N/m and amplitude 0.30 m. As it passes through the centre, a 0.90 kg lump of clay falls vertically on it and sticks.

1. Calculate the block's speed just before the collision.
2. Calculate the speed just after, and the new amplitude.
3. Calculate the new period and compare the total energy before and after.

Problem 20 Mass and period data (hard)

A student hangs masses on a spring and records the period T for each mass m . The mass of the spring is not negligible.

m / kg	0.10	0.20	0.30	0.40	0.50
T / s	0.314	0.425	0.513	0.588	0.654

1. Calculate T^2 for each mass.
2. Find the gradient of the T^2 against m graph using the first and last points.
3. Calculate the spring constant.
4. Explain the small positive intercept.