Physics 20

Unit D: Oscillations and mechanical waves

Simple harmonic motion

A glider returns every 0.628 s

- A 0.250 kg glider on a horizontal air track is pulled 0.060 m to the right of a paint mark and released.
- Each full out and back cycle takes 0.628 s, and the glider keeps reaching that same rightmost point.

Cycle time and the four labels

- Oscillatory motion repeats about equilibrium, and the period T is the time for one cycle.
- Frequency f equals 1 divided by T, so a shorter cycle means a larger frequency in hertz.
- In simple harmonic motion the pull back grows in step with how far you are from the middle. Amplitude is that greatest distance.

Key terms

oscillatory motion

Oscillatory motion is a repeating back and forth motion about an equilibrium position.

simple harmonic motion

Simple harmonic motion is motion due to a restoring force directly proportional to displacement from equilibrium and directed opposite that displacement.

restoring force

A restoring force pulls or pushes an object back toward equilibrium, opposite the displacement. In F = -k x, F is that force, k is the spring stiffness, and x is the displacement from equilibrium. (F = -k x)

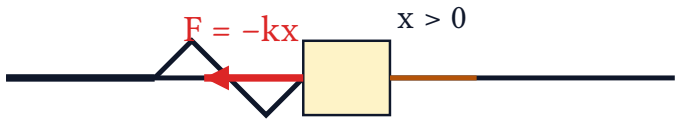
amplitude

Amplitude is the maximum displacement from equilibrium during an oscillation. (A)

The spring force points back

- The force law is F = -k x, with F in newtons, k in newtons per metre, and x the displacement from equilibrium in metres.
- The negative sign means the force points opposite the displacement when the positive direction is away from equilibrium.
- For a horizontal mass spring oscillator, T = 2 pi times the square root of m/k, and m is the mass.

Spring force law



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

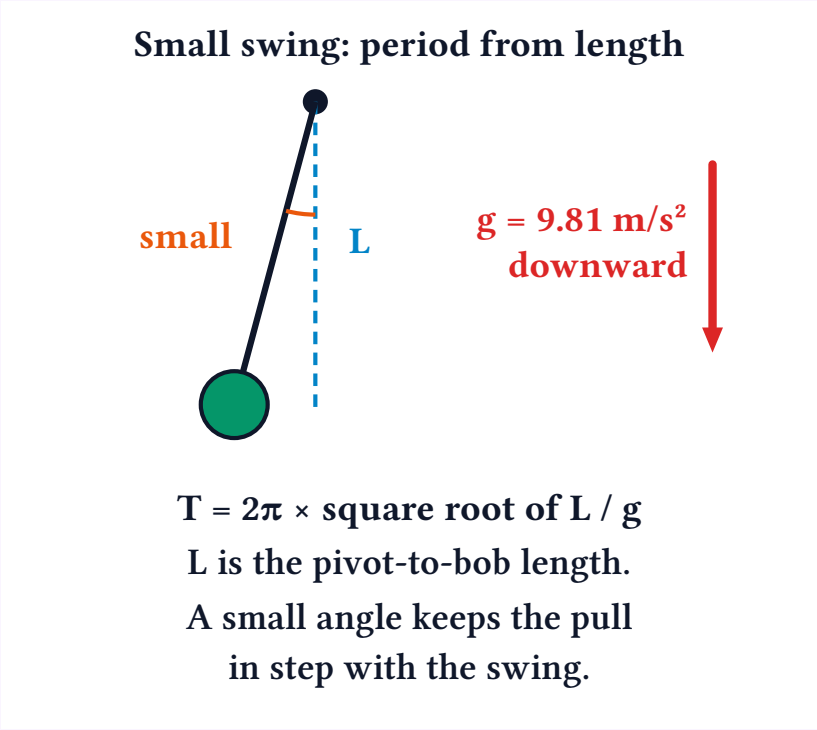
Force points toward equilibrium

Period of a 0.450 kg cart

- A cart of mass 0.450 kg is fixed to a horizontal spring with k = 18.0 N/m.
- T = 2 pi × square root of 0.450 / 18.0 = 0.993 s.
- At +0.080 m, F = -(18.0 N/m)(0.080 m) = −1.44 N.

A small swing and the pendulum clock

- For a simple pendulum at a small angle, T = 2 pi times the square root of L/g.
- The symbol L is the length from the pivot to the centre of the bob, and g is 9.81 m/s squared downward.
- Keep the swing small. Then the pull back grows in step with the distance from the middle.



A stairwell pendulum

- A stairwell pendulum has length 2.20 m and swings through a small angle.
- Find the period with g = 9.81 m/s squared.
- State the speed and the acceleration along the arc at the bottom and at the highest point.

Oscillators

- A 0.200 kg air track glider has k = 50.0 N/m and amplitude 0.040 m.
- Find the period and the restoring force at the positive amplitude.
- State the speed at the amplitude and the acceleration at equilibrium.