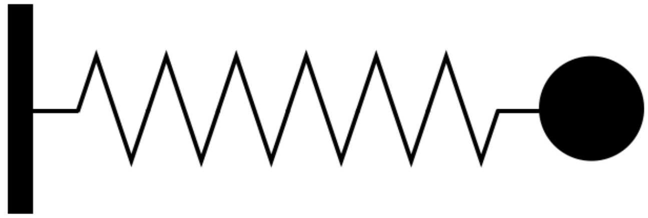
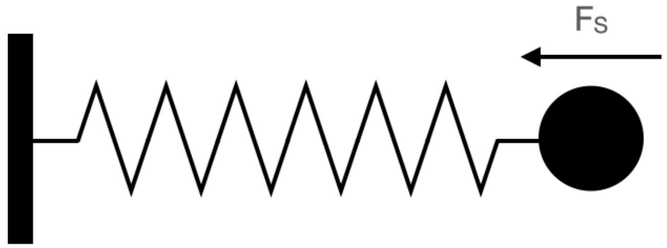
Lesson 1. Oscillation

Imagine a queue-ball attached to the wall of a (frictionless) pool table with a spring. The ball is at rest in a state of **equilibrium**.

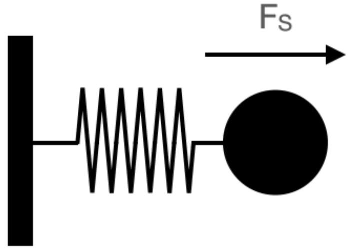


If you were to pull on the ball with force F_1, the spring would extend. The spring's tensile strength would pull back on the ball with restoring force F_S. Since you are holding the ball, these two forces are equal and the ball stays in place.

When you release the ball, force F_1 disappears. Since the restoring force F_S is still present, the ball accelerates in that direction back toward its original equilibrium position.



When the ball passes its original equilibrium position, the forces are once again balanced and the restoring force F_S disappears. However, the ball's momentum carries it past its equilibrium point, compressing the spring and creating a new restoring force in the opposite direction.



This restoring force slows the ball until its momentum reaches zero, at which point the ball stops and the restoring force causes it to accelerate in the opposite direction. When the ball once again returns to its original position, the whole cycle repeats.

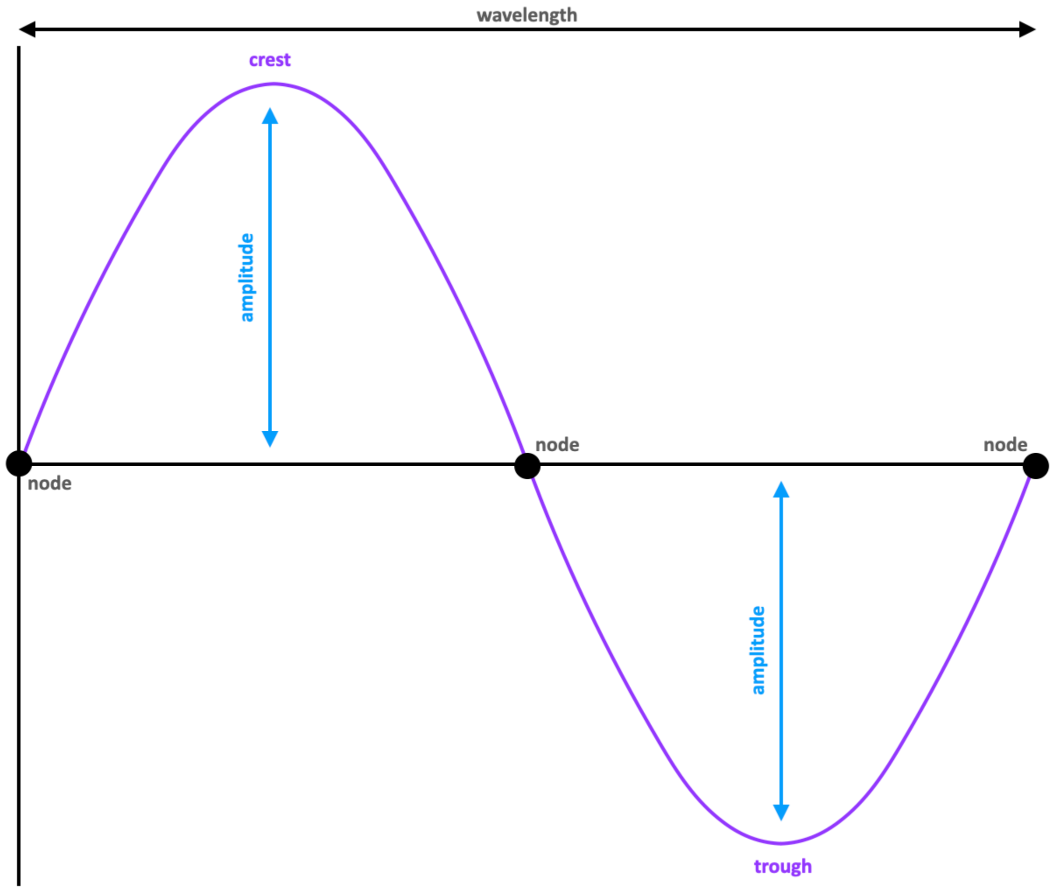
This oscillating motion back and forth around the equilibrium position is called **periodic motion**.

The amount of time it takes to complete one full cycle (from equilibrium to maximum displacement, back to equilibrium to a new displacement, and back to equilibrium again) is called the **period**, represented by a capital T.

The number of cycles completed in one second is called the **frequency**, represented by a lowercase italic *f*.

$$f = \frac{1}{T}$$

Graphing the location of the ball across time gives a **sinusoidal wave**.

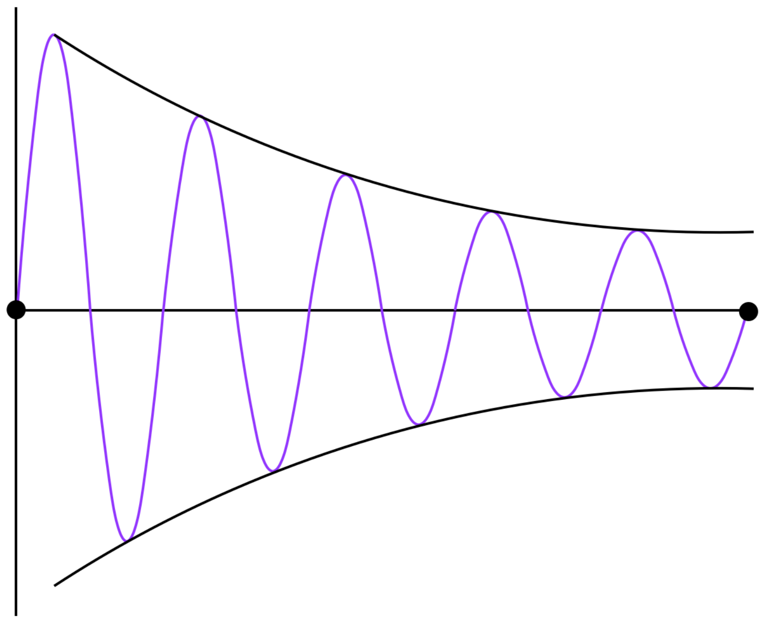


Some sinusoidal wave terminology:

- The length of the full cycle is called the **wavelength**. This is represented by λ.
- Any time the ball crosses its equilibrium position is called a **node**.
- The displacements are called the **crest** and **trough** of the wave.
- The distance from equilibrium to a crest or trough is called the wave's **amplitude**.

The most relevant values of the wave for music are the amplitude, which determines **volume**, and the frequency, which determines **pitch**.

When friction or other resistance is present, the wave will **decay** as it loses energy over time.



The line connecting the successive crests and troughs of each cycle as it approaches zero is called the wave's decay curve or **envelope**.