Anatomy of a Wave

Wave Fundamentals

Waves carry energy through a medium. Although waves look very simple, describing them can get very complicated. They come in many forms, such as light, sound, ocean waves, heat waves, etc. but no matter what form they take, all waves have the same four basic properties: **amplitude, wavelength, period, frequency**, and **speed**.

Amplitude (A) tells us how much energy is in the wave. More energy means a larger amplitude and thus a bigger wave. Think about standing on a beach: some waves are bigger than others, this is because they have more energy. We would say those waves have larger amplitudes than the smaller ones. We give amplitude the mathematical symbol A, and measure it in meters.

Wavelength (λ) is how long a single wave is. In a standing wave, this is the distance it takes a wave to repeat. In other words, it is a measurement from one peak to another or from one trough to another. We could also measure the distance between two nodes on a wave. Wavelength is given the mathematical symbol λ (the greek letter lambda), and can be measured in meters.

The **Period** (T) of a wave is how long it takes one wave to reach a certain point, measured in seconds. For example, if you're standing on a beach and a new wave hits the shore every two seconds, the period of those waves is two seconds. We use the symbol T to represent period.

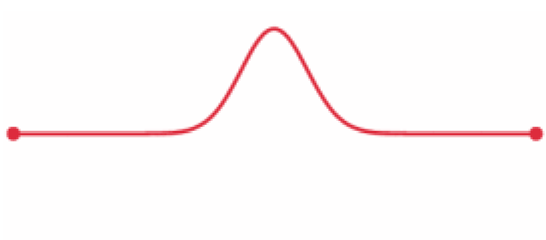
The **Frequency** (f) of a wave is how often a wave passes a point each second. We use f to symbolize frequency in math. Frequency is always 1 divided by the period of the wave, in other words, $f = \frac{1}{T}$. In our example above, the frequency would be $\frac{1}{2}$ because, in one second, half a full wave has hit the shore. Frequency is measured in Hertz, or "cycles per second."

Finally, the **Speed** (v) of a wave is how long it takes a wave to propagate from one point to another in a medium. It is how fast the energy moves from our hand to the other end of a slinky, for example. Mathematically, the speed is equal to the wavelength divided by the period of the wave. $v = \frac{\lambda}{T}$. We can also write this using the frequency instead $v = \lambda f$

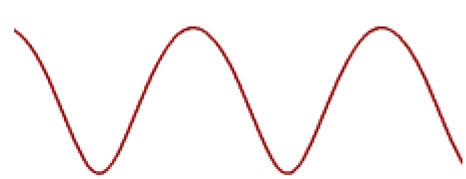
Pulse vs Standing Wave

When we talk about waves, usually what we first think of is a **standing wave**, or a wave that keeps repeating the same pattern, like waves on the ocean or the sound of an alarm. We can also describe a single wave **pulse**, where only a single wave is created and then stops. This is what we made when we flicked the slinkies in our first inquiry.

A wave pulse



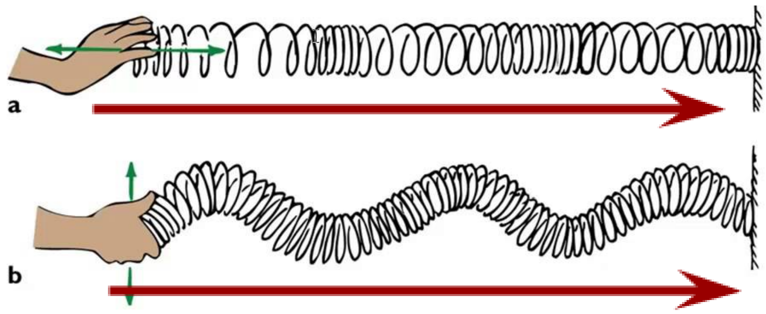
A standing wave



Transverse and Longitudinal Waves

As we have discussed, waves can be either *transverse* or *longitudinal*. We made both types on our slinkies, but here are some more general definitions: a **longitudinal** wave is created when the wave moves perpendicular to the motion of the medium. A **transverse** wave is created when the wave moves in the same direction as the motion of the medium. To see the difference, think about how you had to move the slinky to get the shapes in the diagram below.

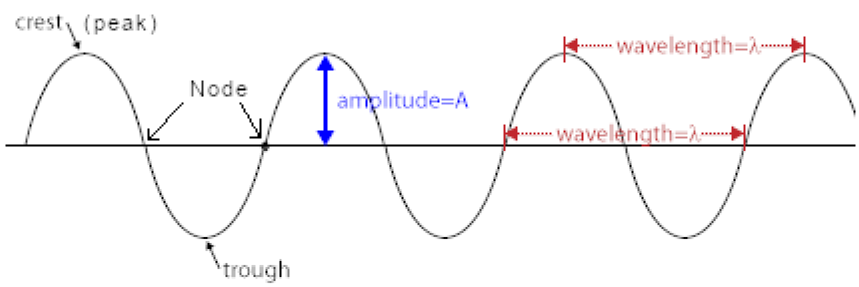
In both (a) and (b), the energy is traveling from left to right. In (a) the slinky is also moving left to right, so the wave is longitudinal. In (b) the slinky is moving up and down, so the wave is transverse.

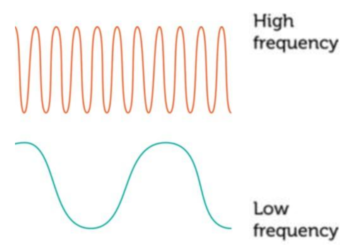


Energy is moving to the right

Anatomy of a Transverse Wave

We can talk a bit more about the specifics of both types of waves. The highest points on a transverse wave are called **peaks** (or **crests**), while the lowest points are **troughs**. In between each peak and trough is a **node**, a point where the medium (such as the slinky) isn't actually moving. It's caught perfectly in between being pulled up and down, so it says still.

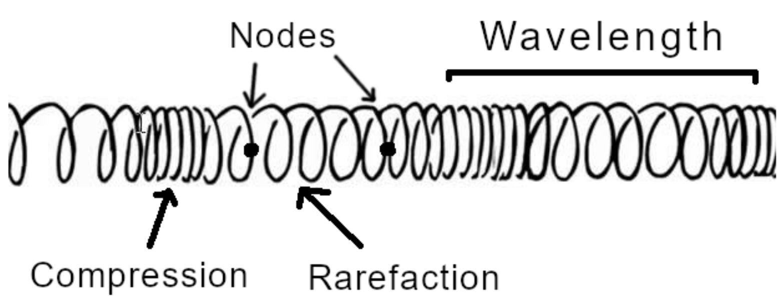




Anatomy of a Longitudinal Wave

Longitudinal waves have similar properties. Instead of peaks, they have **compressions**, where the medium is the *most dense* or squeezed. Instead of troughs they have **rarefactions**, where the medium is the *least dense* or stretched out. It's hard to see, but they also have **nodes** in the middle of each compression and rarefaction.

Amplitude is also harder to see on a longitudinal wave. It would be the amount of squeeze or stretch at each compression or rarefaction. So a higher amplitude means the coils of our spring are desner, or more tightly squeezed, at each compression.



Vocabulary Banks

Term	Symbol	Definition	Units Used
Amplitude	A	The height of the wave, determined by the energy it has.	meters
Wavelength	λ	How long a single wave is	meters
Period	T	How long it takes a standing wave to repeat	seconds
Frequency	f	How many waves appear in a standing wave each second; more waves in less time means higher frequency	Hertz (cycles/second)
Speed	v	How fast a wave moves through a medium	m/s

Term	Definition
Medium	What the wave travels through; water, air, a slinky, space, our bodies, etc.
Wave	Motion that lets energy move through a medium without the medium displacing
Wave Pulse	A single wave that doesn't repeat but can move back and forth
Standing wave	A series of repeating waves that make a steady shape.
Node	A spot on a standing wave that does not move
Longitudinal	A wave that moves forward and backward
Compression	The most squeezed part of a standing wave
Rarefaction	The most stretched part of a standing wave
Transverse	A wave that moves up and down
Peak/Crest	The top of a transverse wave
Trough	The bottom of a transverse wave