

Ripples in (Space)Time

Information in Waves

NB: This article is for readers with prior knowledge of physics

Waves occur all around us in nature. The light we see is made up of electromagnetic waves. These waves can be reflected off smooth surfaces, like mirrors, just like sound waves (although their ability to reflect depends greatly on the quality of the surface). Earthquakes are caused by seismic waves travelling through the Earth's crust. Gravitational waves, which ripple outwards from moving objects within the universe, such as black holes, move at the same speed as electromagnetic waves—the speed of light.

Today, we use electromagnetic waves to send and receive information through cables and wirelessly through the air.

Wireless communication is the only option for internet connectivity for devices like tablets and smartphones. Thankfully, to use wireless communication, we just need to know how to add a wi-fi network to our device, which network to pick, and its password.

However, you may have also found yourself wondering, "What is wi-fi?" The simple answer is that it is a wireless networking technology and an example of wireless communication.

But to dive deeper, let's consider a scenario. Imagine there are two people, Korra and Tenzin. Korra visits Tenzin's house, and asks Tenzin, "What's your wi-fi password?"

What's a wave?

A wave is an oscillation that transfers energy.

Fun Fact

There is a common misconception that "wi-fi" is short for "wireless fidelity" but it is not. It was created by the Institute of Electrical and Electronics Engineers but the trademark is now owned by the Wi-Fi Alliance, and the term "wi-fi" was created by a marketing firm and doesn't have any significant meaning.

How is information sent in this case?

A request for information, in the form of Korra's question, is being sent from Korra (wirelessly!) through the air and is received by Tenzin in the form of sound waves. These sound waves, which store information in the form of air pressure, are created by Korra's vibrating vocal cords and travel through the air. The sound waves from Korra that make it to Tenzin's ears cause little hairs (called cilia) in Tenzin's ear canals to vibrate. His brain then deciphers the changing air pressure into words, thus allowing wireless communication between Korra and Tenzin.

A similar process is employed for wireless communication in smartphones and tablets. Korra's and Tenzin's vocal cords and ears are replaced by antennas, and the sound waves are replaced by electromagnetic waves. For the purpose of wireless communication, the message is sent as electromagnetic waves that are created and transmitted by supplying electrical signals to transmitting antennas. The message is then received by a receiving antenna, in which electrical signals are created (or induced) when it receives electromagnetic waves.

Electromagnetic waves can be transmitted in particular patterns (like Morse code) to encode information, which is similar to the way sound waves encode our words when we speak. For electromagnetic waves, this pattern is called modulation, because we modify (or modulate) the signal.

A Nod to Avatar

The names Korra and Tenzin come from the animated show Avatar.





Consider a car radio: there are both AM and FM radio stations.

AM stands for amplitude modulation. Amplitude refers to the size of the wave. For sound waves, a larger amplitude means a louder sound, while for electromagnetic waves, a larger amplitude means a stronger signal. So, with amplitude modulation, information is encoded in a carrier electromagnetic wave by modifying how large the signal is. (The carrier electromagnetic wave carries the information from a transmitting antenna to a receiving antenna.)

FM stands for frequency modulation. Frequency is how quickly a wave completes a cycle. For sound waves, an example of a high-frequency wave would be the sound waves created by someone whistling, and a lower frequency wave would be their regular speaking voice. For electromagnetic waves, we only need to look at a rainbow: the red end of the rainbow is made of lower frequency electromagnetic waves, and the blue/violet end of the rainbow is made of higher frequency electromagnetic waves.

It sounds like nature intended life to be full of ups and downs.

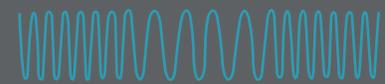
Signal



AM



FM



Fun Fact

The electromagnetic spectrum contains a range of frequencies and wavelengths, most of which are not visible to the human eye. Colour is the only sliver of the spectrum that is visible.

