

Adapted from State of Delaware TOE Unit

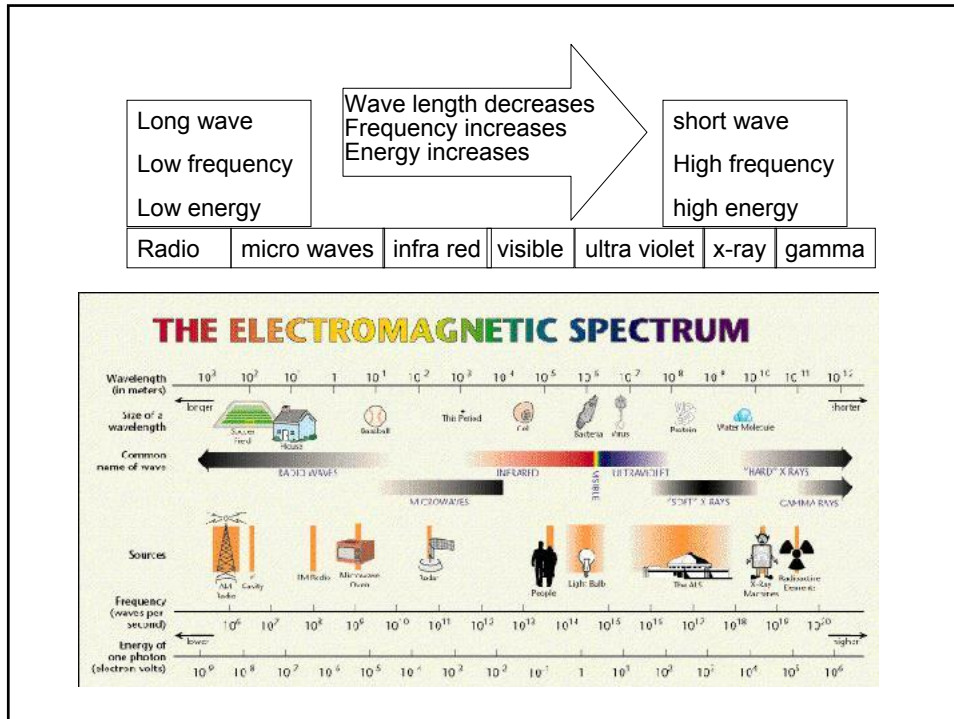
MAKING SENSE OF ENERGY ... Electromagnetic Waves

GOALS: In this Part of the unit you will...

- Learn about electromagnetic waves, how they are grouped, and how each group of waves is important in our lives.
- Learn which characteristics of a wave determine how much energy it carries.
- Learn about visible light waves and how the energy carried by these waves enables us to see.
- Learn what can happen when a wave strikes a substance, and how it delivers energy to a substance.
- Learn that the different groups of waves behave differently when they strike substances. These differences can have an important impact on the substances.

MAIN IDEAS:

- Electromagnetic waves have many of the properties of mechanical waves, but in other ways they behave very differently than mechanical waves.
- We divide the electromagnetic spectrum into seven smaller groups of waves. Waves within a group have similar properties.
- Visible light waves are especially important because the energy carried by these waves enables us to see.
- Substances accept energy from waves through a process called absorption. When energy is absorbed by the substance, it is transformed into a different energy form.



How Do Electromagnetic Waves Compare to Mechanical Waves?

Earlier we learned that the organized vibrations of particles in matter cause mechanical waves.

If there are no particles to vibrate, there will be no mechanical waves.

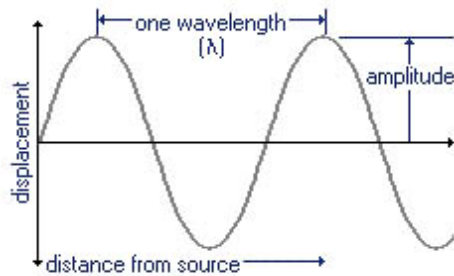
This is why mechanical waves must travel through matter, and cannot travel through the vacuum of empty space.

What Characteristics of a Wave Determine How Much Energy It Can Deliver?

Electromagnetic waves transport energy as TRANSVERSE waves.

Amplitude: The 'height' of the wave is related to the wave's **amplitude**. As the amplitude of the wave increases, the energy it carries increases too.

Frequency: The greater the frequency of a wave, the greater the number of cycles that are completed every minute, which means more energy is delivered by the waves every minute.



The characteristics of a wave that indicate **how much energy** it carries are the **amplitude** and the **frequency** of the wave. This is true for mechanical waves and electromagnetic waves.

Similarities between electromagnetic waves and mechanical waves.

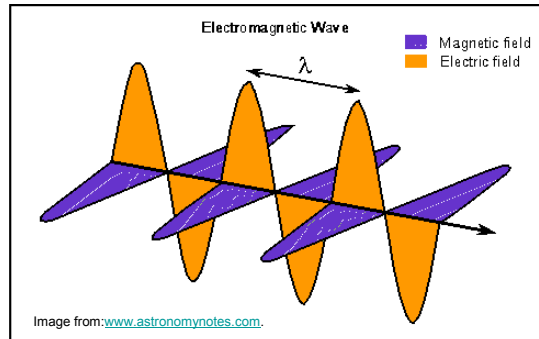
- Electromagnetic waves carry energy, but do not transport matter.
- Electromagnetic waves can be described in terms of frequency, wavelength, and wave speed (velocity).
- Electromagnetic waves **can** travel through matter, but **don't have** to.

Differences between electromagnetic waves and mechanical waves

- Mechanical** waves **carry kinetic** energy, but **electromagnetic** waves **carry electric** energy and **magnetic energy**.
- Mechanical waves result in the organized vibration of particles, but **electromagnetic waves** can travel where there are **no particles**.
- All electromagnetic waves travel **much faster** than mechanical waves do.

Electromagnetic waves are disturbances in the electric and magnetic fields that exist in space.

These fields are created by particles that contain electric charge. Moving charges create electric fields and magnetic fields. These fields have no mass, and they can extend out great distances from the charges that create them.



Scientific Content:

- Visible light waves carry energy that activate our sense of sight. We see objects when light leaving these objects enters our eyes and begins a series of energy transfers and transformations that enable us to see.

- Very often, when waves strike a surface, they divide. Some of the waves reflect off of the surface and the rest enter the material.

- The waves that **reflect** off of the surface **carry** their **energy away** from the material.

- The waves that pass through the surface enter the substance and carry their energy into the material. Once inside the material, the waves can continue to travel, and then leave the material, and/or they can be absorbed by the material.

- If **waves are absorbed, their energy is transformed** into a different form within the material.

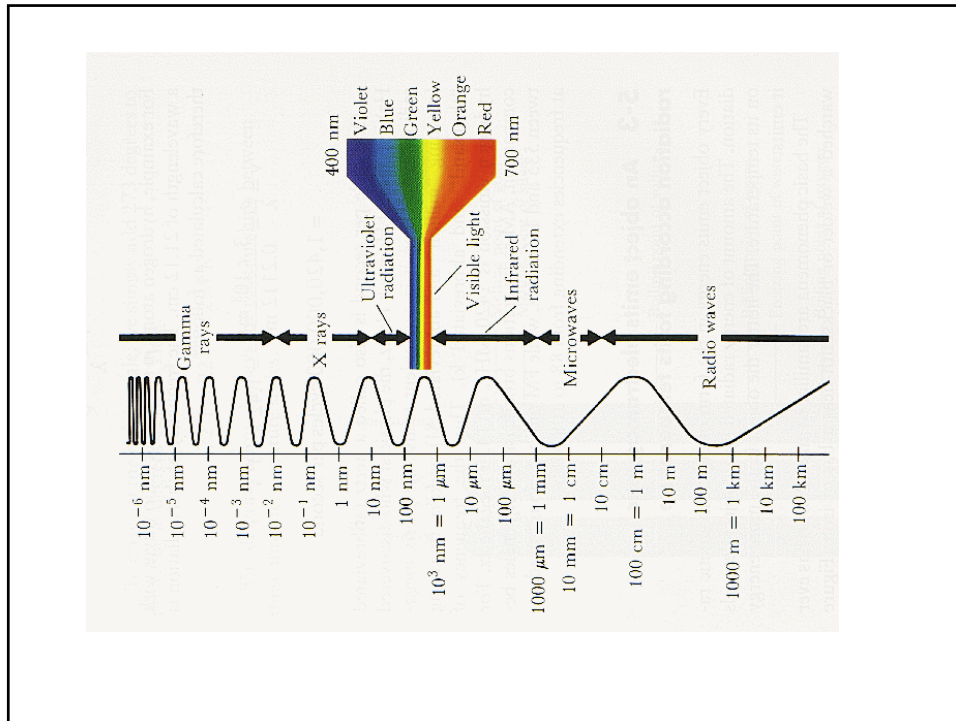
- If **waves pass through (transmitted)** the material, they carry their **energy** along **with them**.

•The different groups of waves behave differently when they strike substances. The behavior depends on the type of electromagnetic wave and the properties of the substance.

•Ultraviolet waves can be harmful to your health because of the energy they carry. They can damage or destroy molecules in the body and lead to problems like skin cancer and cataracts in the eyes. Sunscreen absorbs U.V. waves and transform them to thermal energy. If the energy has been transformed to thermal, it can no longer damage the skin cells.

•Infra Red waves can be absorbed by materials and transformed to thermal energy. This is how the Earth is warmed. U.V, Visible Light and Infra Red reach the surface of the Earth from the Sun. The Infra Red is absorbed and transformed to thermal energy warming the surface.

•The thermal energy of an object can be transformed by the particles of the object into a form of electric and magnetic energy that can be carried away by electromagnetic waves called infra red waves. This process is referred to as cooling by radiation.



Taking a Look at Light ...

Electromagnetic waves that have wavelengths roughly five ten millionths (that's 5/10,000,000) of a meter long make up the group of waves called visible light.

Numbers that small are difficult to grasp. Put differently, it would take a visible light wave roughly 2,000 wavelengths long to reach across this circle →°.

Visible light represents far less than 1/7 of the electromagnetic spectrum. In fact, it is the narrowest range of wavelengths of all of the seven groups of the electromagnetic waves.

They are singled out for one reason; humans have eyes that are sensitive to the energy carried by electromagnetic waves that have wavelengths in this range.

When we see, it seems like we are looking out into the world through those dark holes (called pupils) in our eyes.

It is easy to believe that we see by sending something out of our eyes (maybe even some form of energy) to probe the outside world.

In fact, the opposite is true. We see objects because light leaves those objects and enters our eyes. Light must enter our eyes for us to 'see'.

Waves of visible light carry energy that triggers the sense of sight in our eyes. The only way that this energy can help us see is if the waves carrying it enter our eyes.

When the waves enter an eye, they are focused by our eye onto a small screen on the back of the eye. The screen is made of many receptors (roughly 100 million!)

These receptors transform the energy carried by the light waves into a form of electrical energy.

The electrical energy from the receptors is carried by nerves to the brain.

When the electrical energy reaches the brain, it is interpreted by the brain and finally, we 'see' the object we are looking at.

