

HOW DO SUNGLASSES WORK?



Studying Light Polarization and Attenuation

What Do Sunglasses Do?

Brainstorm in your groups:

What are the key objectives of good sunglasses?

- ❑ To reduce the glare
such as reflecting

- ❑ To protect the eyes from ultraviolet (UV) light

—so we need to study and understand the basic properties of light
prevent eye damage


Engineers do this sort of brainstorming and analysis all the time,
PLUS they also need to **understand the science**
—so we need to study and understand the basic properties of light



Light Polarization

Lesson Objectives

By the end of this lesson, you will be able to:

- Explain light polarization
 - Describe methods to polarize light
 - Explain light and electromagnetic wave attenuation
- 
- A series of several parallel white lines of varying lengths and orientations, located in the bottom right corner of the slide, creating a dynamic, abstract graphic element.

Electromagnetic Wave Structure

Review

Q: What is the cause of electromagnetic radiation?

Electromagnetic waves are caused by vibrating electric charges.

Q: What are the two distinct waves of electromagnetic waves?

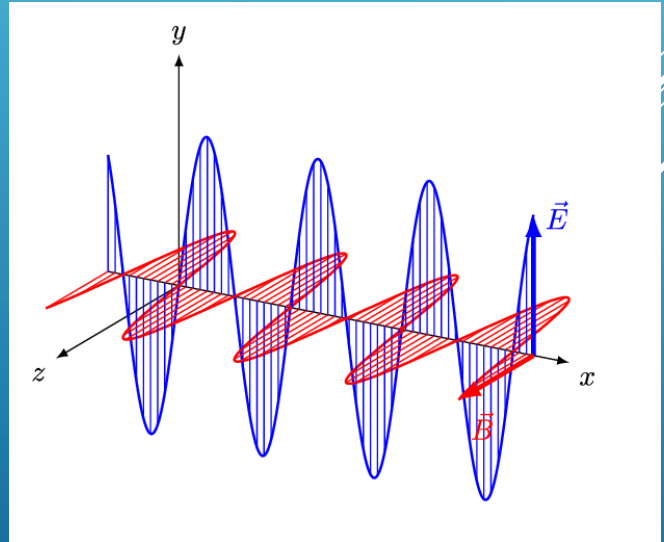
Are they transverse or longitudinal?

Electromagnetic waves have 2 components:
electric and magnetic

This means that each EM wave (light included)
has 2 distinct **transverse** waves

-1 from the vibration of the electric field

-1 due to the vibration of the magnetic field



Light Characteristics & Polarization

- ❑ Since light is an electromagnetic wave, it shares the same characteristics. **What are these light properties?**
 - Travels at 3.0×10^8 m/s
 - Travels in straight lines
 - Has more than one disturbance
- ❑ Since light (and all electromagnetic waves) has more than one disturbance, it also has more than one polarization
> using this fact, **discuss with your group the meaning of polarization**

Light Polarization

Polarization refers to the direction of the vibration

Since the electric charges of electromagnetic waves vibrate in multiple directions, **light is unpolarized**

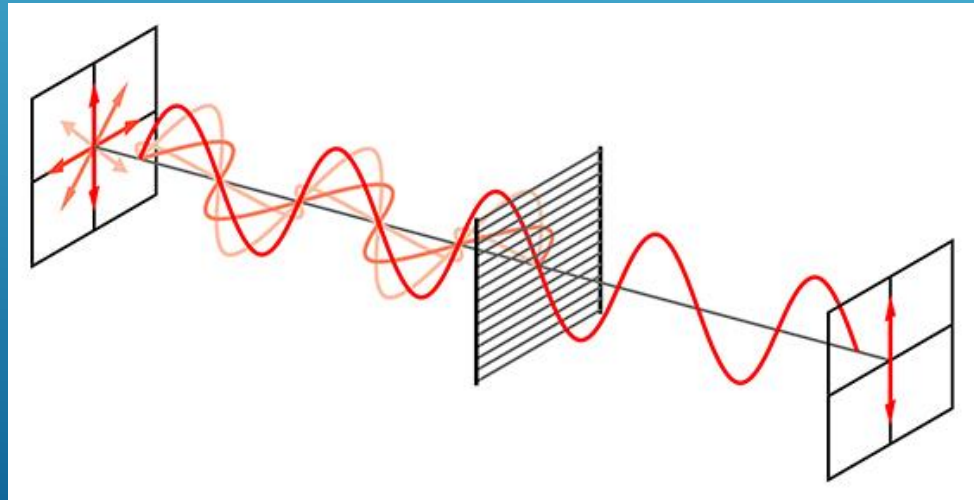
Q: What are some ways in which the light polarization can change?

1. **transmission**
 2. **reflection**
 3. **refraction**
 4. **scattering**
- 
- A decorative graphic consisting of several parallel white lines of varying lengths and orientations, located in the bottom right corner of the slide.

Transmission “Filter” Method

- ❑ The polarization of light can change by passing it through polaroids
- ❑ **Polaroids** are special filters that are chemically designed to let through only a specific polarization of light
- ❑ As light passes through the polaroid film, it becomes polarized

Describe the polarization of the light in this diagram →



Polarization by Transmission

Using the polaroid films, answer the following questions:

Q: What happens when you look at unpolarized light through the polaroid film?
Explain why you think this is.

The light intensity seems to be cut in half.

This is because the filter actually filters out half of the light.

Mini-
Activity

Q: What happens when you look at unpolarized light through 2 polaroids?
Be sure they are parallel. Explain why you think this is.

In this case, the light intensity does not look any different than before because the light is already polarized in that direction, so the light can still pass through.

Q: Now slowly begin rotating one of the polaroids until it is perpendicular to the other.
Explain what happens to the light. Why do you think this is?

As the polaroid is rotated, the light intensity decreases. This is because the already polarized light is being filtered again by the second polaroid. Eventually, no light is able to pass.

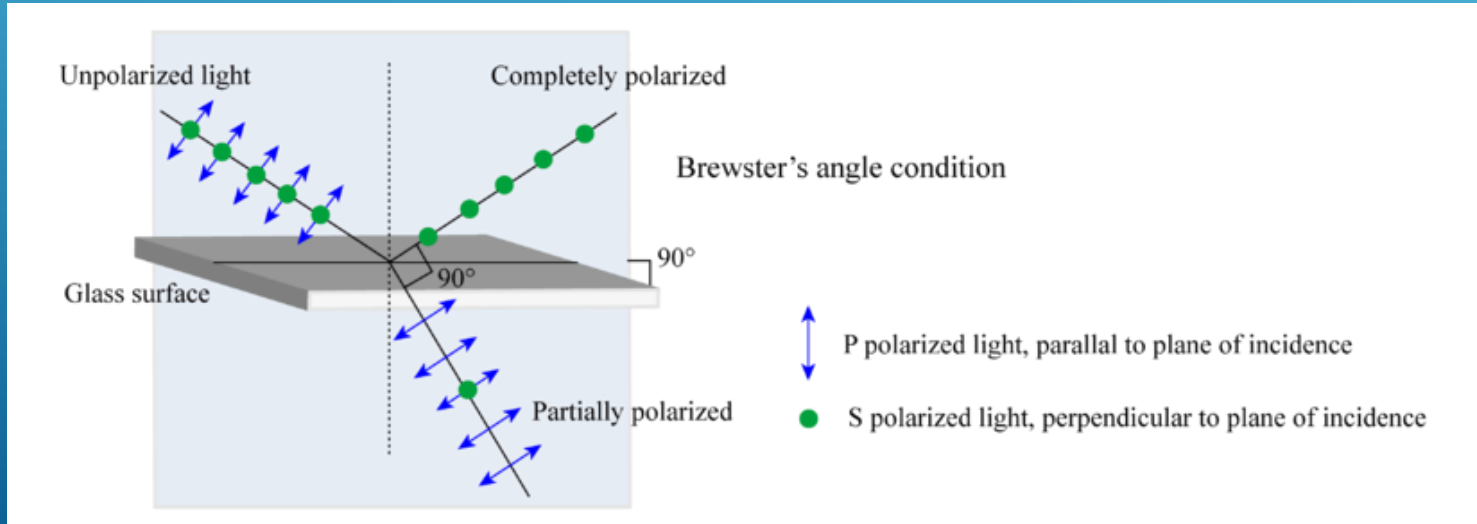
Reflection Method

Q: What happens when light strikes any surface?

The surface either absorbs or reflects the light

When light reflects off a non-metallic surface, such as a road or water, it changes its polarization

The polarization of light depends on the plane of the surface and the angle of incidence



Reflection Method

Not all reflected light changes the polarization.

As light hits a **non-metallic surface**, the surface vibrations cause the polarization to change

- For instance, the ground is flat and lies horizontally
- As light strikes the ground, the horizontal wave begins to vibrate more frequently than the vertical wave, and the light becomes horizontally polarized
- This causes the **glare** we see when driving!
- We wear sunglasses to reduce the glare



Discuss in your group: ***What type of polarizing filter do sunglasses use to reduce glare?***

Polarizing Polarized Light??

- ❑ We have an equation for light intensity when subject to different polaroids
- ❑ The angle between 2 polaroids is important in determining the light intensity

Malus' law describes how the intensity changes when polarized light passes through a second polaroid

$$I = I_0 \cos^2 \theta$$

I = Intensity of light after leaving second polaroid.
 I_0 = Intensity of light before entering second polaroid.
 θ = Angle between two polaroids.

Quick Check!



Light Attenuation

Q: What happens to light intensity as it passes through a polaroid film?

The light intensity decreases

Q: This is what we call **light attenuation**.

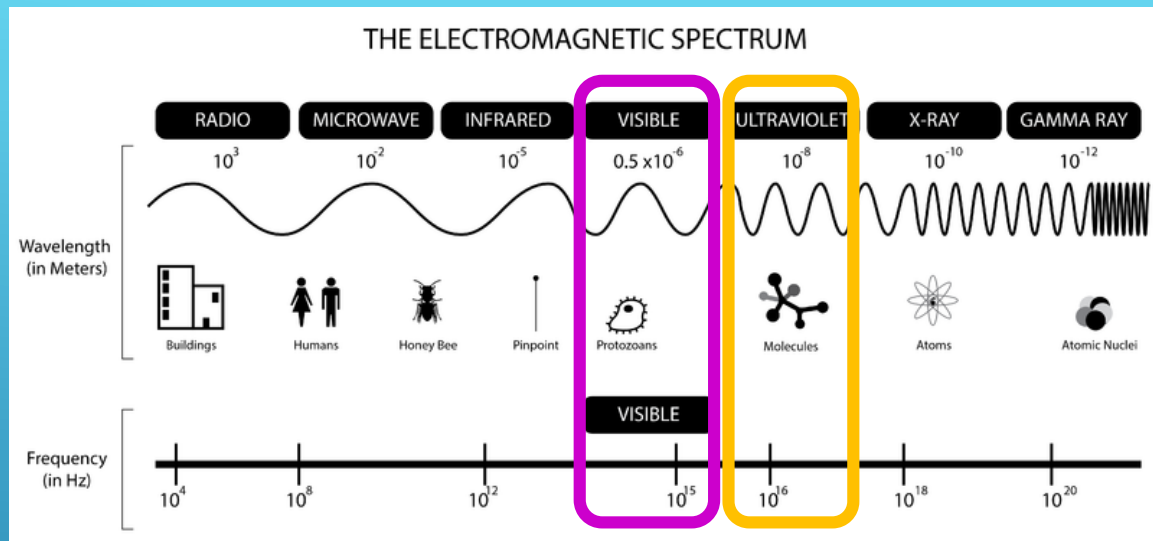
What is the definition of **attenuation**?

The reduction of intensity or power of an electromagnetic wave
All electromagnetic waves attenuate through different materials

Q: Different wavelengths/frequencies attenuate differently through different materials

For example, 60 GHz waves are completely blocked by humans, but 2 GHz waves attenuate only slightly when passing through our bodies

Light Attenuation



Q: When designing sunglasses, which portion(s) of the electromagnetic spectrum need(s) to be attenuated?

- visible light
- ultraviolet light

Q: Normally, a plastic lens does not attenuate these wavelengths/frequencies. What can we do to attenuate them?



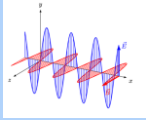
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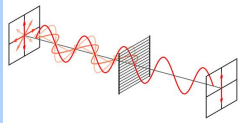
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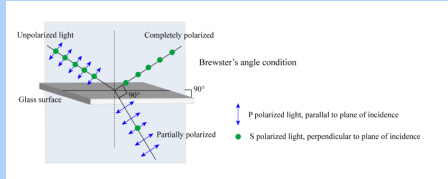
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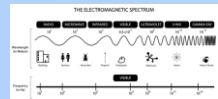
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