

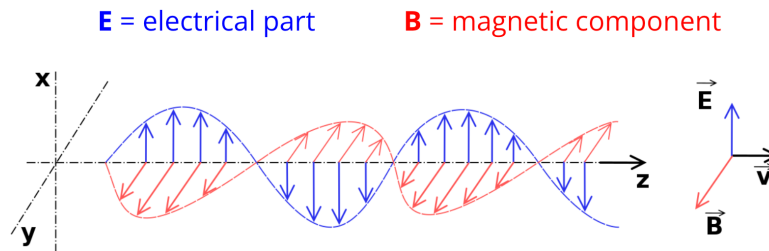
## Polarization and Polaroid Filters Lesson Notes

### Learning Outcomes

- What is polarized and unpolarized light?
- What does the process of polarization involve?

### What is an Electromagnetic Wave?

An **electromagnetic wave** is a wave that travels through material objects **AND** through empty space with a fluctuating electrical and magnetic signal.



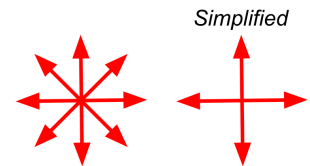
Source: [https://commons.wikimedia.org/wiki/File:Onde\\_electromagnetique.svg](https://commons.wikimedia.org/wiki/File:Onde_electromagnetique.svg)

### Polarized vs. Unpolarized Light

Light - a transverse, electromagnetic wave - can be thought of as being one of two types:

#### Unpolarized Light:

Light vibrating in a multitude of directions (or multiple planes)



### What Does a Polaroid Filter Do?

A Polaroid filter has its molecules aligned in one direction.

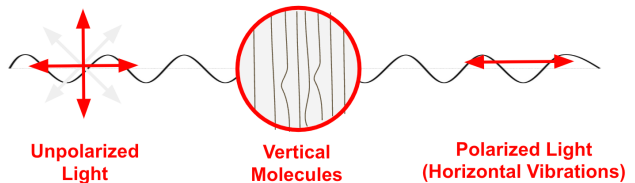
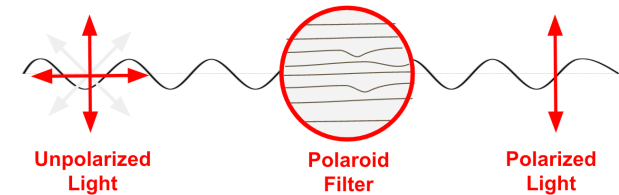
Vibrations that are aligned with the molecules are absorbed; vibrations perpendicular to the molecules pass through.

The light emerging from the filter is polarized and has one-half the original intensity.

Molecule direction matters; vibrations  $\perp$  to molecules pass through.

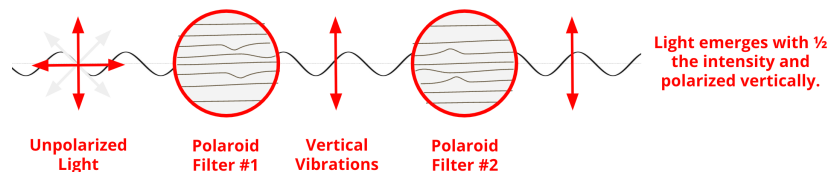
#### Polarized Light:

Light vibrating in a single direction (or a single plane).



### 2 Filters; Molecules II to Each Other

Suppose unpolarized light approaches two consecutive Polaroid™ filters, with their molecules parallel to each other. Filter #1 blocks  $\frac{1}{2}$  the light and polarizes it in a single direction. Filter #2 has no effect.

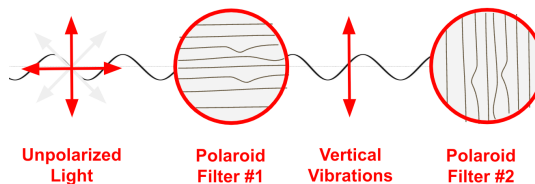


## 2 Filters; Molecules $\perp$ to Each Other

Suppose unpolarized light approaches two consecutive Polaroid™ filters, with their molecules parallel to each other.

Filter #1 blocks  $\frac{1}{2}$  the light and polarizes it in a vertical direction.

Filter #2 has vertical molecules that block the remaining light.



There is no light emerging from the second filter ... total darkness.

## Why Two Filters Can Block All the Light

When two Polaroid filters have their molecules aligned perpendicularly, the first filter blocks one-half the light.

The second filter blocks the remaining half. No light exits the second filter.

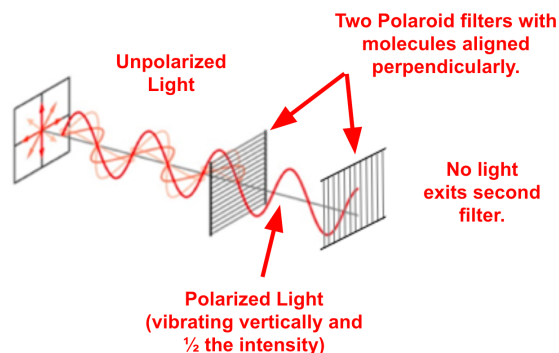


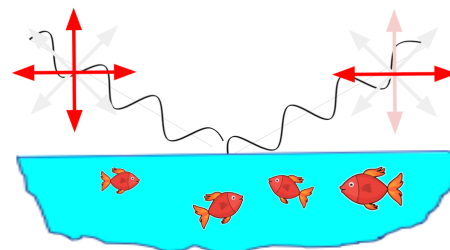
Image adapted from Wikimedia Commons:

<https://commons.wikimedia.org/wiki/File:Wire-grid-polarizer.svg>

## Application: Sunglasses

When light reflects off of non-metallic surfaces (like roads and lakes), it becomes partially polarized in a direction parallel to the surface. This results in an annoying glare to an observer.

The use of sunglasses with Polaroid filters can block this glare. The molecules of the filter should be aligned horizontally to block the horizontal vibrations.



## Application: 3-D Movies

- 2 movies shot with 2 cameras
- 2 projectors equipped with Polaroid filters; molecules aligned  $\perp$  to each other
- 2 movies showing on 1 screen
- 2 eyes equipped with Polaroid filters; molecules aligned  $\perp$  to each other
- 1 brain receiving information from 2 eyes
- 3 dimensions



Physics for Better Living!

## Four Common Processes that Polarize Light

1. Use of a Polaroid Filter.
2. Reflection off a non-metal surface.
3. Passage through the atmosphere.
4. Refraction through certain crystals.

