Polarization

SP212 - General Physics II

UNITED STATES NAVAL ACADEMY
ANNAPOLIS

Polarization

The direction that the <u>electric</u> field oscillates in is said to be the direction of the wave's polarization.

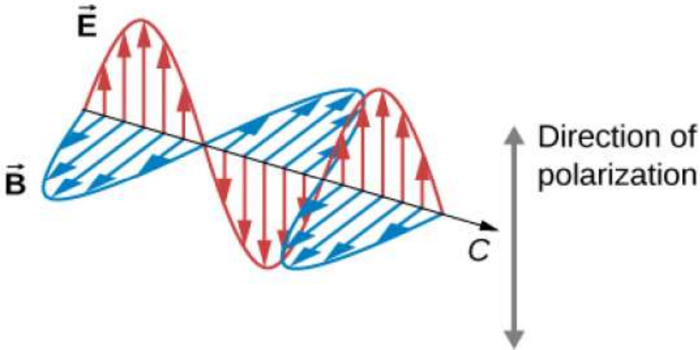
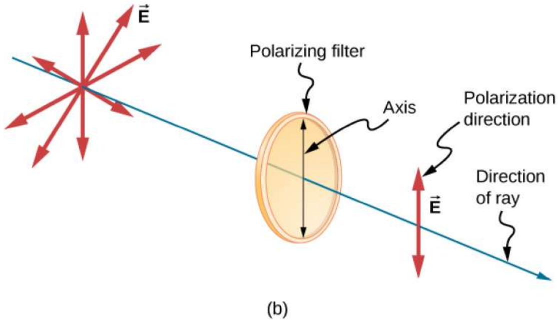


Image is Figure 1.33 from *OpenStax University Physics Vol. 3*; access for free at openstax.org

Polarization

When unpolarized light passes through a polarizer (or polarizing filter), only light that is polarized along the filter's axis will make it through.



$$I = \frac{1}{2} I_0 \qquad \text{Unpolarized light through a filter}$$

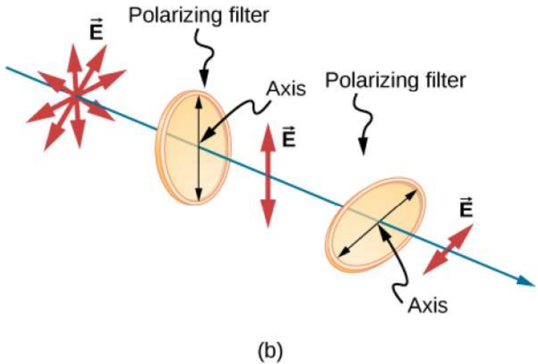
- I_0 is initial intensity of the unpolarized light going into the polarizer
- I is final intensity of the polarized light making it out of the polarizer
- Intensities: units are W/m^2

Figure 1.35(b) from *OpenStax University Physics Vol. 3*

When polarized light passes through a polarizer, the intensity goes down and the outgoing polarization changes to the axis of the polarizer.

$I = I_0 \cos^2 \theta$ Malus's Law

- I_0 is initial intensity of the polarized light going into the polarizer
- I is final intensity of the polarized light making it out of the polarizer
- Intensities: units are $\mathrm{W/m^2}$
- θ is the angle between the initial light's polarization and the axis of the polarizer



If $\theta = 0^\circ$ then $I = I_0$ If $\theta = 90^\circ$ then $I = 0$

Figure 1.36(b) from *OpenStax University Physics Vol. 3*

Example:

Unpolarized light of 120 $\mathrm{W/m^2}$ intensity passes through two polarizer. The transmission axis of the second polarizer is rotated 30° from the axis of the first. What intensity of light makes it through both polarizers?

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$I = \frac{1}{2} I_0$ for unpolarized light passing through a polarizer. Therefore 60 W/m^2 is the intensity of light making it through the first polarizer. This light is polarized, along the axis of the polarizer.

$I = I_0 \cos^2\theta$ for polarized light passing through a polarizer. That gives $(60\ \mathrm{W/m^2})\cos^2 30° = 45\ \mathrm{W/m^2}$ as the intensity of light passing through the second polarizer.

Polarization via reflection

When unpolarized light reflects off of a surface, the reflected and refracted rays will often be at least partially polarized. The reflected light will be mostly polarized in the direction parallel to the surface (usually horizontally).

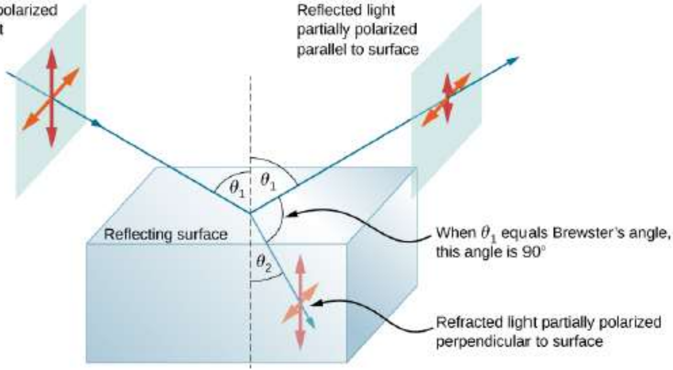

Figure 1.38 from *OpenStax University Physics Vol. 3*

Brewster's Angle

There is a particular angle θ_p, known as Brewster's angle or the polarizing angle. When the incident angle matches this ($\theta_1 = \theta_\mathrm{p}$) the reflected light will be fully polarized. It turns out that when this is true (when $\theta_1 = \theta_\mathrm{p}$) the reflected and refracted beams will be 90° apart.

$$\tan \theta_\mathrm{p} = \frac{n_2}{n_1}$$ Brewster angle (polarizing angle)

- θ_p is Brewster's angle or the polarizing angle.
- n_2 is the index of refraction for the second material
- n_1 is the index of refraction for the first material (the material the incident and reflected beams are in)

Glare (reflection off water for example) is mostly horizontally polarized. Polarizing sunglasses have a vertical transmission axis to block the glare.