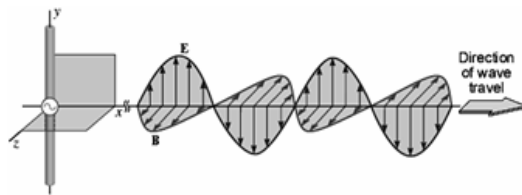
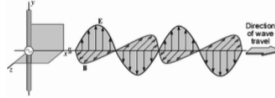


Polarization of Light

Production of EM waves: oscillating electric charge produces varying electric and magnetic fields

Transverse: vibration is perpendicular to direction of motion of energy

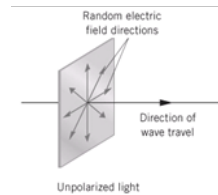
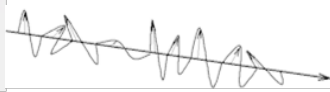
Speed: all EM waves travel at 3.00×10^8 m/s in a vacuum



Polarization of Light

Unpolarized Light –

light in which the electric field vector vibrates in **random directions**



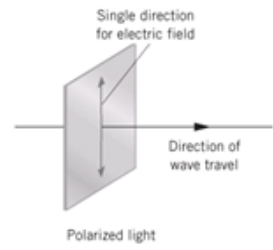
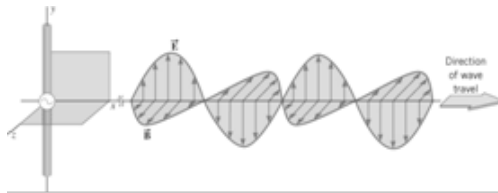
Examples: **light bulb, sun**

Polarization of Light

Polarized Light –

light that only moves in 1 direction

light in which the electric field vector vibrates in **..one plane only**



Plane of Polarization:

plane in which the electric field vector vibrates

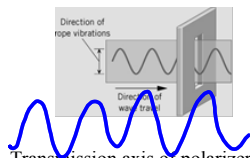
Methods of Polarization

a) Polarizing filter

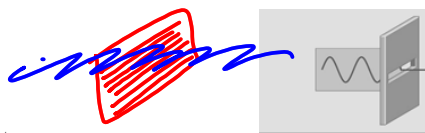
Polarizer-material that produces...**Plane polarized light from an unpolarized beam**

Transmission axis-direction of polarization that...a polarizer allows through

Simple model of a polarizer using a wave on a rope



Transmission axis of polarizer is parallel to the plane of polarization of the wave

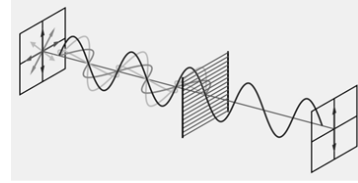


Transmission axis of polarizer is perpendicular to the plane of polarization of the wave.

Note: **only transverse waves can be polarized-not longitudinal waves**

Note: **light can be polarized but not sound**

How is a polarizing filter made?



A Polaroid polarizing filter was in its original form an arrangement of many microscopic crystals.

Its later form is made from polyvinyl alcohol (PVA) plastic with an iodine doping. Stretching of the sheet during manufacture particular direction. Electrons from the iodine dopant are able to travel along the chains, ensuring that light polarized parallel to the chains is absorbed by the sheet (resonance); light polarized perpendicularly to the chains is transmitted.

Therefore: The transmission axis is . . . **perpendicular to the direction of the long chain molecules**

APPLICATION - IMAX 3-D films - The movies are recorded on two separate rolls of film, using a camera that provides images from the two different perspectives that correspond to what is observed by human eyes and allow us to see in three dimensions. The camera has two apertures located at roughly the spacing between our eyes. The films are projected using a projector with two lenses. Each lens has its own polarizer and the two polarizers are perpendicular.

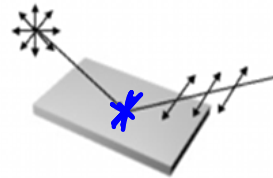
In one type of theater, viewers watch the action on-screen using glasses with corresponding polarizers for the left and right eyes. Because of the crossed polarizers the left eye only sees the image from the left lens of the projector and the right eye sees only the image from the right lens. Since the two images have the approximate perspectives that the left and right eyes would see in reality, the brain combines the images to produce a realistic 3-D effect.



b) Reflection from a non-metallic plane surface

Sunlight is unpolarized. When sunlight is incident on an object, part of the light will be absorbed by the object (or refracted inside the object) while the rest of the light will be reflected by the object. This reflected light is partially to completely polarized, depending on the angle of incidence.

The polarization direction will be in the same direction as the surface of the object, that is, the plane of polarization for the reflected light is parallel to the surface of the object. Sunlight striking the surface of water or a road are examples where reflected light will be polarized. This is often called *glare*.

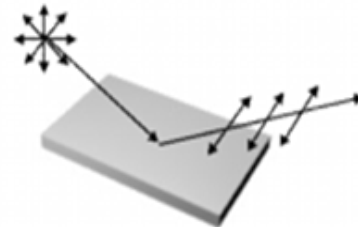


What is glare?

Reflected light that is polarized

What is the direction of polarization of glare?

Parallel to surface (horizontal)

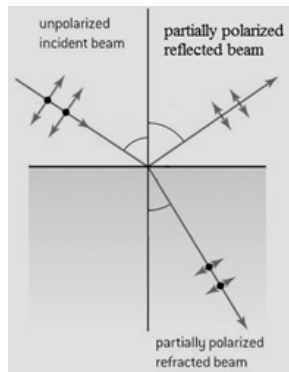


How do polarized sunglasses reduce glare?

Transmission axis is vertical – does not allow glare to pass through since glare is light that has been horizontally polarized by reflection from non-metallic surface

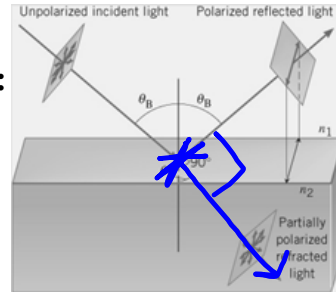


In 1809 the French experimenter Etienne-Louis Malus showed that when unpolarized light reflected off a glass plate it could be polarized to a degree that depended on the angle of incidence (left). In 1812 the Scottish physicist Sir David Brewster showed that when unpolarized light incident on the surface of an optically denser material (such as glass or water), at an angle called the polarizing angle (or Brewster's angle), the reflected ray would be completely polarized. At this angle the reflected ray and the refracted ray are at right angles (right).

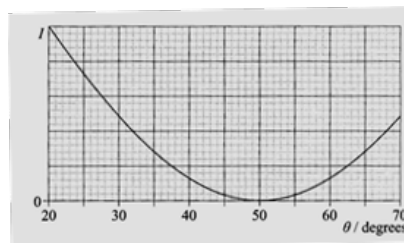
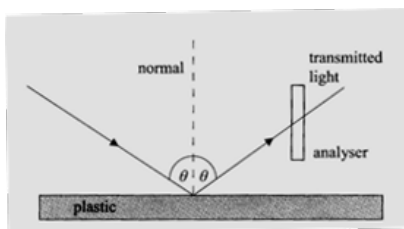


Brewster's Angle (θ_B):

$$\tan \theta_B = \frac{n_2}{n_1}$$



1. Unpolarized light is incident on the surface of a plastic. The angle of incidence is θ . The reflected light is viewed through a polarizing filter whose transmission axis is vertical. The variation with θ of the intensity I of the transmitted light is shown in the graph.



a) Explain why there is an angle of incidence for which the intensity of the reflected light transmitted through the polarizing filter is zero.

Light reflected off plastic is partially polarized for other angles but completely polarized parallel to the surface (horizontal) at this angle ($\theta_B = 50^\circ$) and so cannot pass through a vertical polarizer