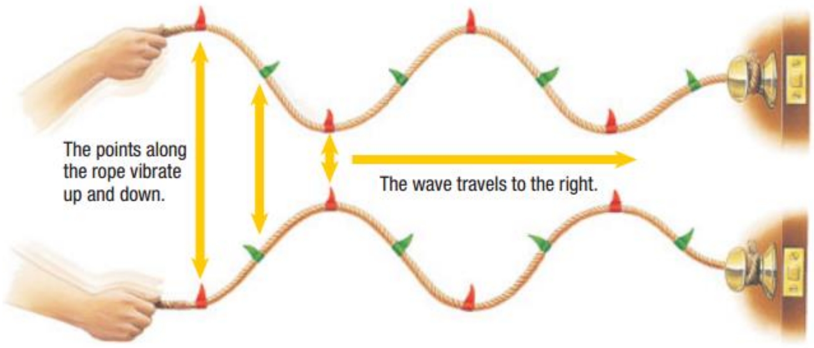
Polarization

IB PHYSICS | WAVES - LIGHT

Light is a Transverse Wave



This isn't the whole story though…

When unpolarized, light can be thought of as oscillating at every perpendicular to the wave's motion

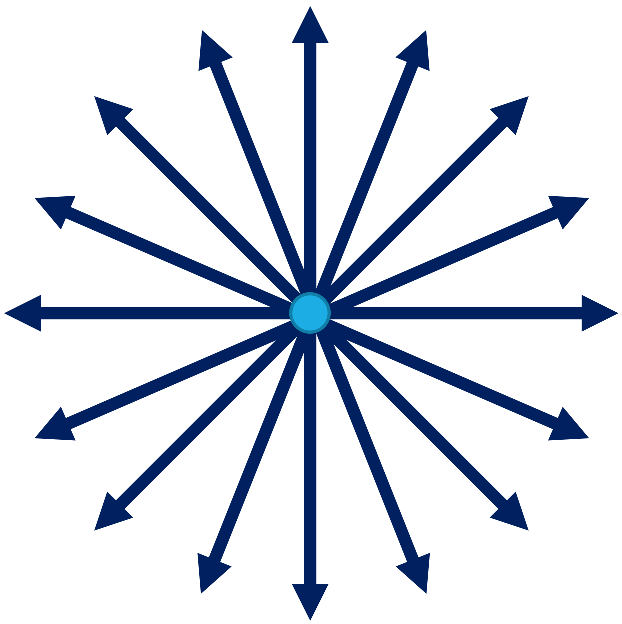
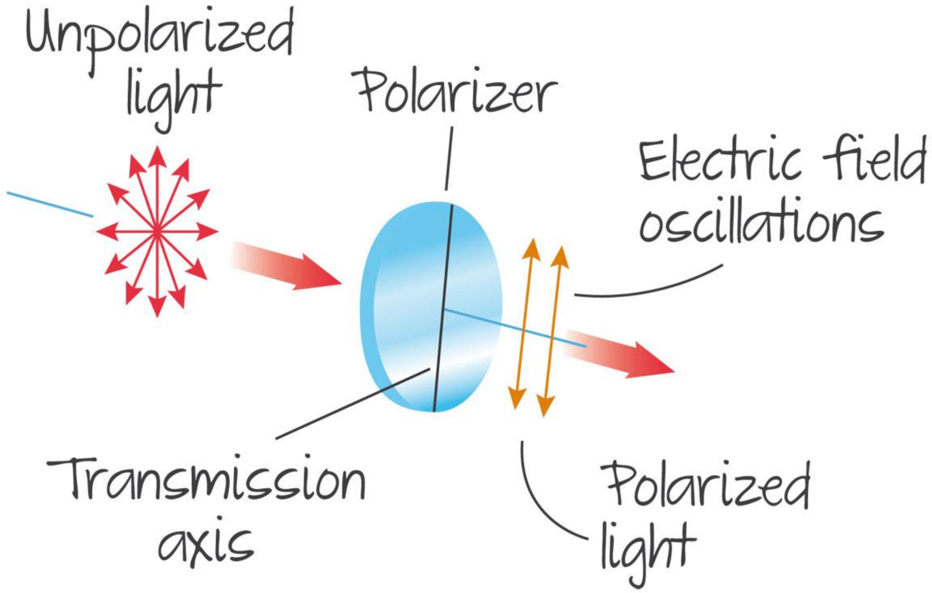


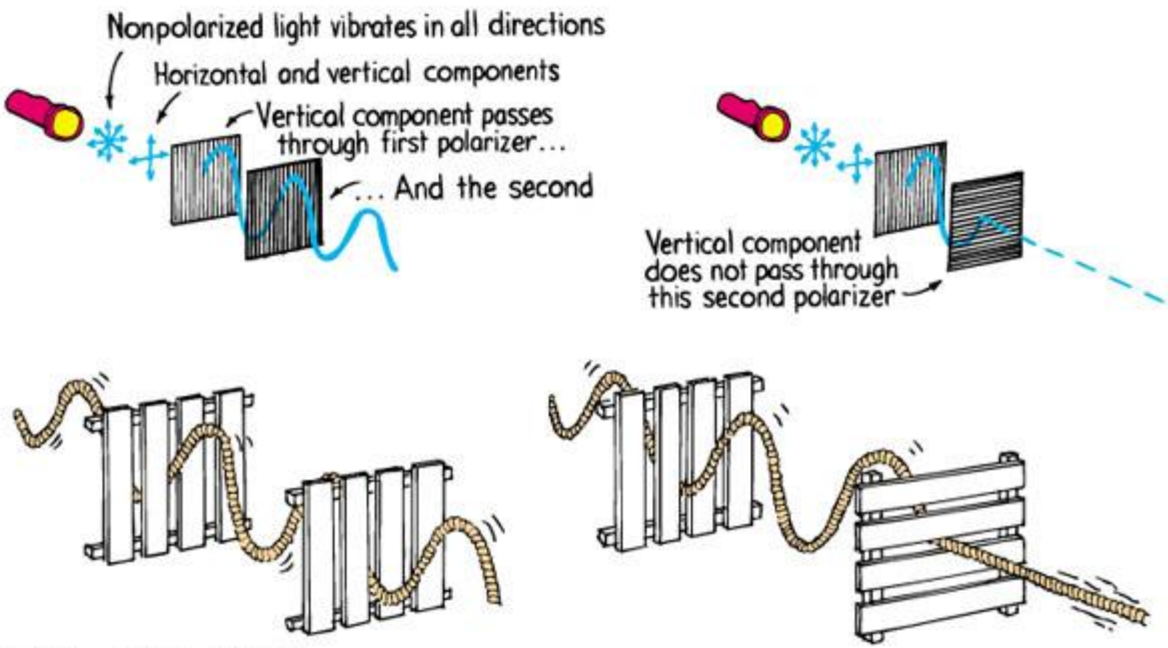
Diagram of a light ray coming out of the page

Polarizers

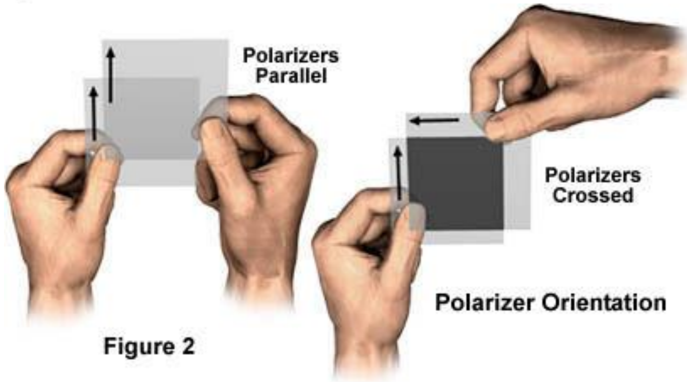


Unpolarized light loses 50% intensity when passing through a polarizer

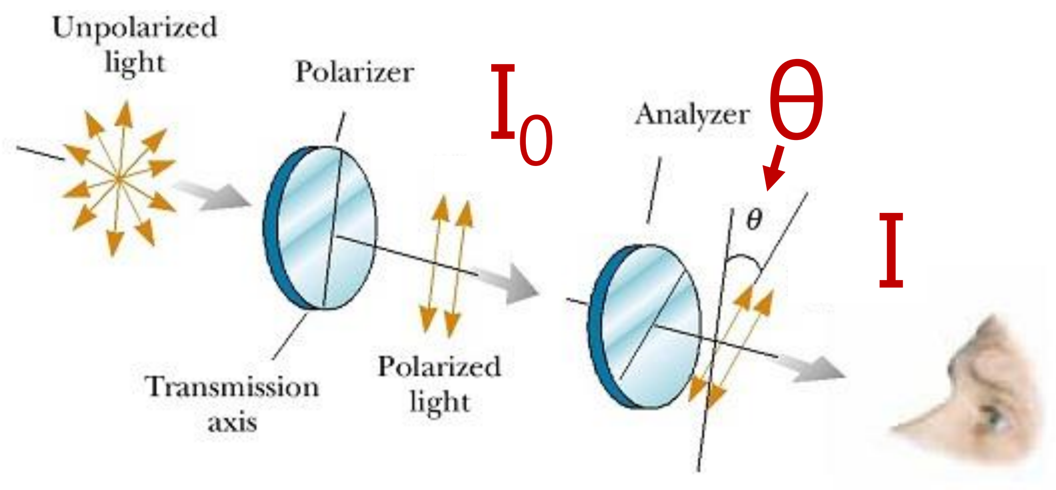
Polarized Light



Hewitt, *Conceptual Physics*, Ninth Edition.



Malus' Law



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

θ = angle between filters

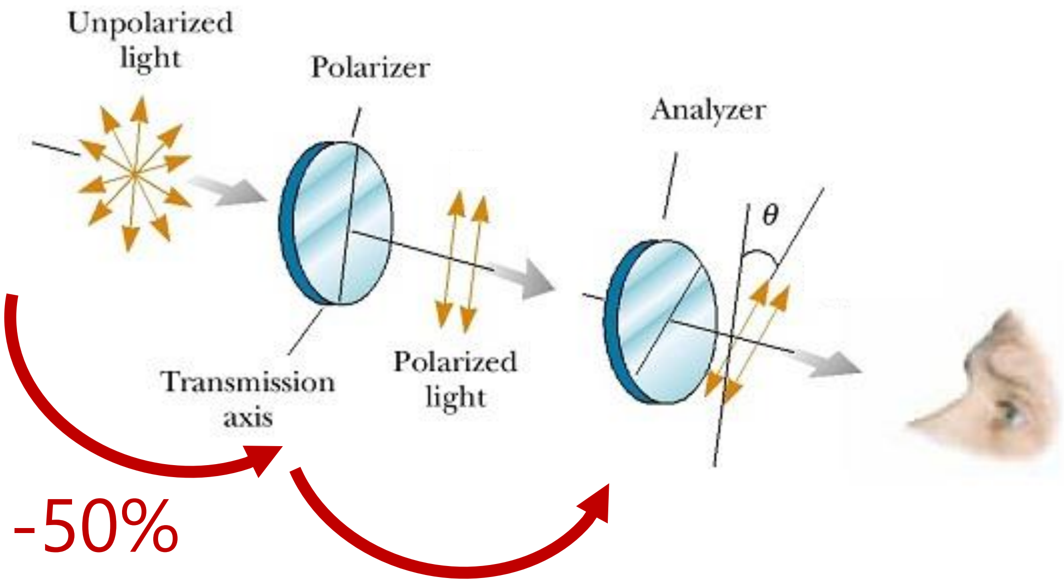
Same thing as

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

IB Physics Data Booklet

Sub-topic 4.1 – Oscillations	Sub-topic 4.4 – Wave behaviour
$T = \frac{1}{f}$	$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$ $s = \frac{\lambda D}{d}$ Constructive interference: path difference $= n\lambda$ Destructive interference: path difference $= (n + \frac{1}{2})\lambda$
Sub-topic 4.2 – Travelling waves	
$c = f\lambda$	
Sub-topic 4.3 – Wave characteristics	
$I \propto A^2$ $I \propto x^{-2}$ $I = I_0 cos^2\,\theta$	

Loses Intensity Twice



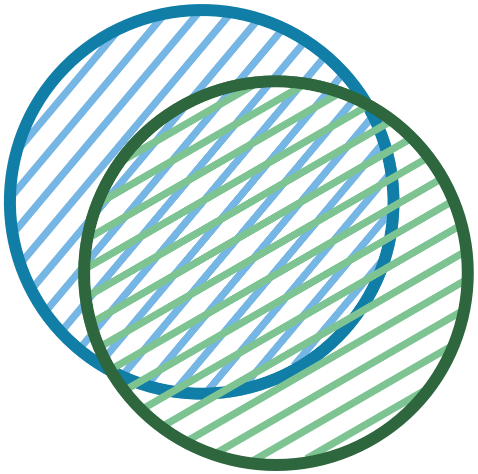
$$I = I_0 \cos^2\theta$$

50% loss when unpolarized light is polarized

Equation calculates loss through subsequent filters

Angle Difference

The intensity of plane polarized light, at 40° to the vertical is I_0. After passing through an analyzer at 60° to the vertical, what is the intensity measured?



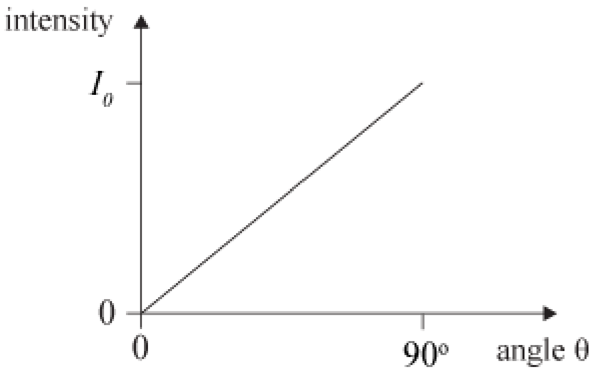
$$\theta = 60° - 40° = 20°$$

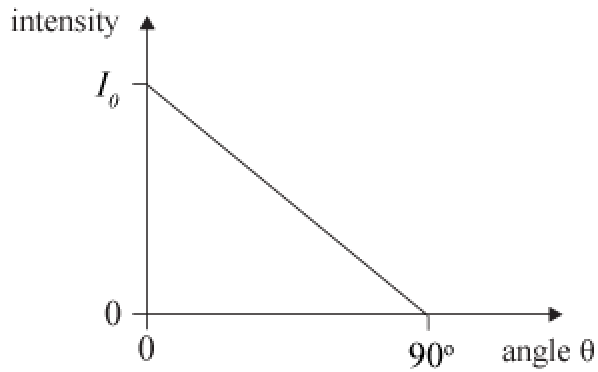
$$I = I_0\, cos^2(20°) = 0.883\, \boldsymbol{I_0}$$

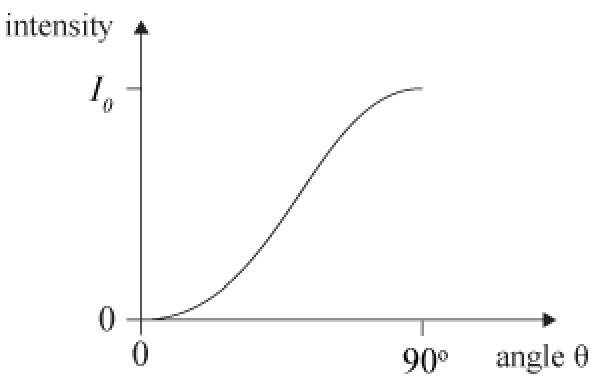
88.3% of the original intensity

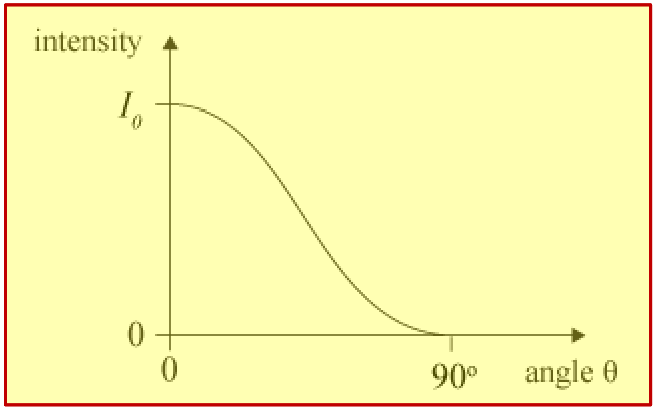
Sample IB Question

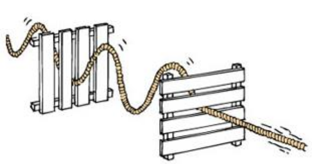
Polarized light of intensity I_0 is incident on a polarizing filter. The angle between the plane of polarization of the incident light and the transmission plane of the polarizer is θ. Which graph shows how the intensity I of the light transmitted through the polarizer varies with θ?











90° → Intensity = 0

$\cos^2$ shape

Try this Calculation

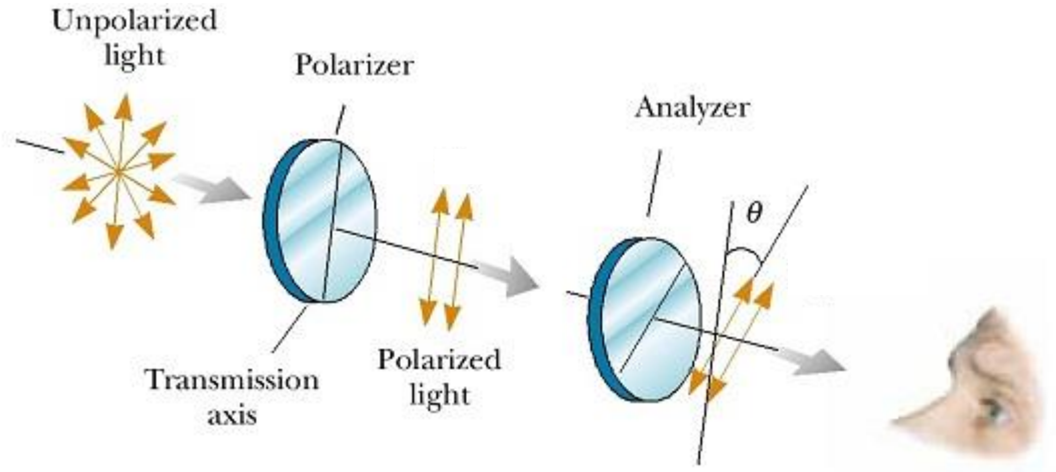
After passing through one polarized filter, the intensity of vertically polarized light is 60 W m^{-2}. What is the angle of the analyzer relative to the vertical if the intensity observed is 20 W m^{-2}?

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

$$20 = 60\,(\cos\theta)^2$$

$$I = I_0\,(\cos\theta)^2$$

$$\theta = \cos^{-1}\left(\sqrt{\frac{20}{60}}\right) = \mathbf{54.7°}$$

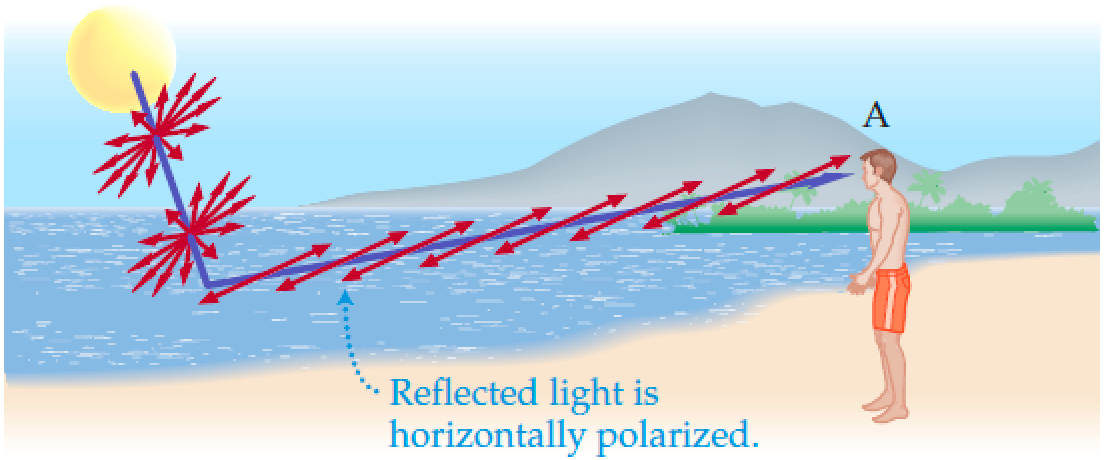


What was the intensity of the unpolarized light?

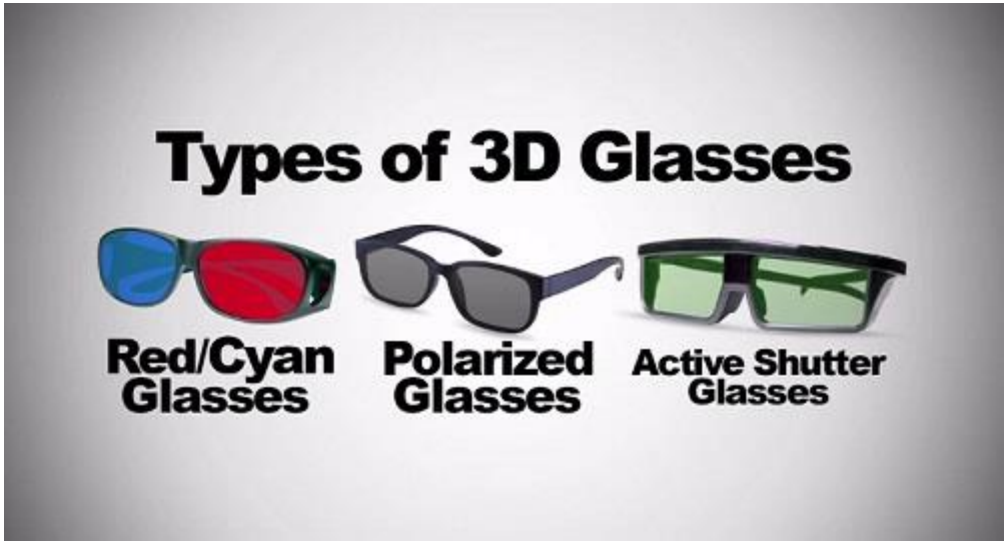
120 W m^{-2}

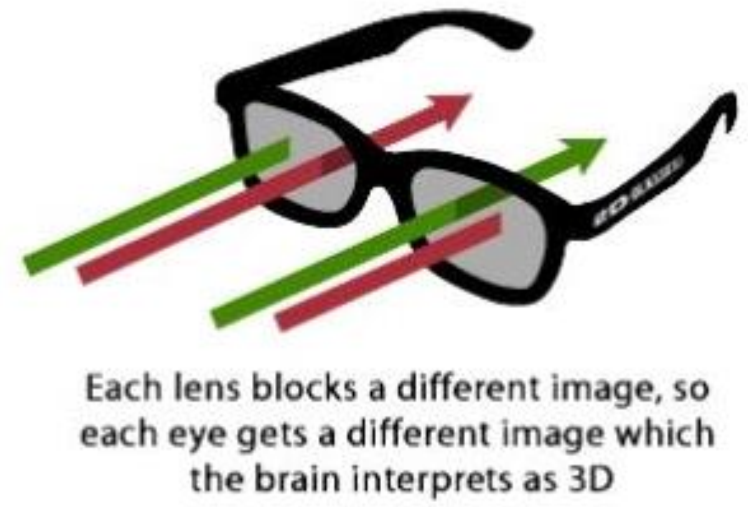
Loses 50% from first filter

This isn't the only way



What about 3D Movies?





Lesson Takeaways

- ❑ I can describe the transformation that takes place when unpolarized light is polarized
- ❑ I can describe the interaction between two polarized filters at different orientations
- ❑ I can use Malus's Law to calculate the change in intensity when passing through polarized filters