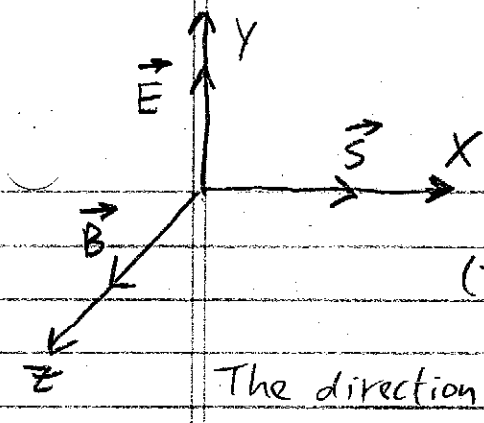
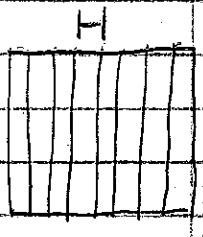


Polarization — Recall that light is a transverse wave.
(The oscillation is ⊥ to the direction of propagation.)

The direction of polarization = the direction of the $\vec{E}$ field.
This is usually random (unpolarized), for white light.



A polarizer is a filter that passes only light with the $\vec{E}$ field in one direction (for example, along the y axis).
Polarizers use long chains of hydrocarbon molecules (for visible light) or wire grids (for radio waves) or atoms in crystals (for X-rays).

Polarizers polarize the light.

A 2nd polarizer is called the "analyzer" — it can show the effect of polarization when rotated.

Malus's law — $I = I_{max}\cos^2(\theta)$ as the book says (eq. 37-9),

but I prefer to write it:

$$I = I_{max}\cos^2(\theta_2 - \theta_1),$$

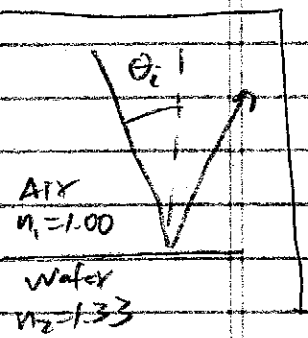
where $\theta_2 - \theta_1$ = the angle between the transmission axes of the two polarizers.

Since $\frac{1}{2\pi}\int_0^{2\pi}\cos^2\theta\, d\theta = \langle\cos^2\theta\rangle = 1/2$,
(The mean value of $\cos^2\theta$ over a cycle)

$\langle I/I_{max}\rangle = 1/2$ $\Rightarrow$ Two polarizers pass only $I_{max}/2$, even when $\theta_2 - \theta_1 = 0$.

Polarization by reflection – Reflection polarizes light, parallel to the surface.

A reflected beam will be completely polarized when $\theta_i = \theta_p$, Brewster's angle, also called the polarizing angle,



where $\tan \theta_p = n_2 / n_1$,
where n_2 = the reflecting medium (e.g. water, with $n_2 = 1.33$)
and n_1 = the other medium (e.g. air, with $n_1 \simeq 1.00$).

$\theta_p = \arctan(1.33/1.00)$
$= 53^\circ$

This is also why polaroid sunglasses should have their transmission axes oriented vertically.

Polarization by double refraction = birefringence – certain crystals can split light into O (ordinary) (n_O) and e (extraordinary) (n_e) rays.

Polarization by scattering –
for example, by dipolar air molecules, which is Rayleigh scattering, causing Earth's blue sky,

or by needle-shaped dust grains, which is Mie scattering, causing red sunsets.

Show – Pleiades