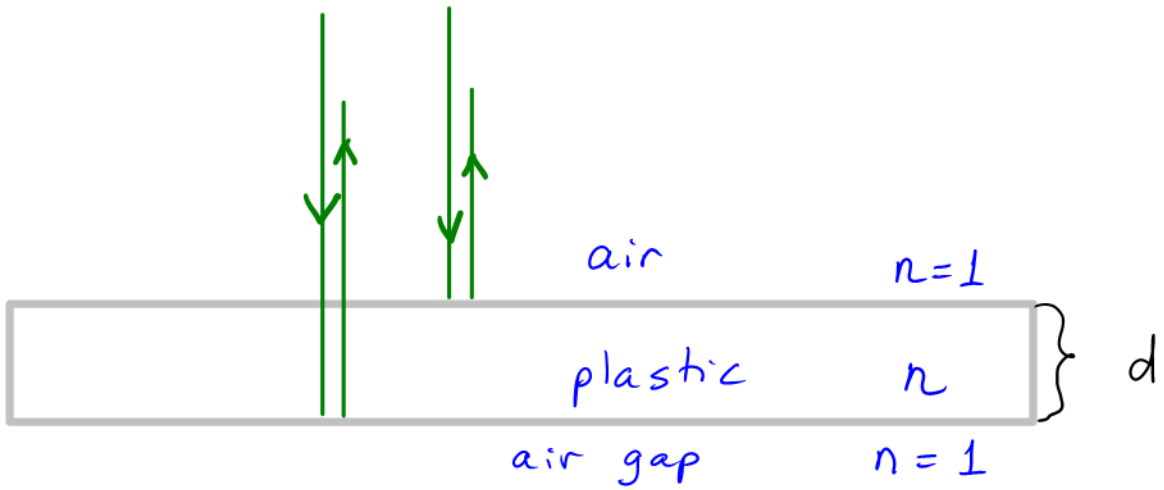
PhysicsTutor

Thin-Film Interference

Giordano 25.18

Problem:

- A plastic film of thickness 250 nm appears to be green (wavelength 500 nm) when viewed in reflection at normal incidence.
- What is the plastic's index of refraction?



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- A phase change occurs at the first surface (air-plastic) reflection, but not at the second.
- The optical path length of light travelling through a medium is the physical length times the refraction index for the medium.

Equations associated with ideas:

optical path length : $2nd$

phase : $\phi_2 = 2nd \cdot \frac{2\pi}{\lambda}$ for wave that reflected inside

$\phi_1 = \pi$ for top-reflected wave

interference condition : $\phi_1 + \phi_2 = 2m\pi$

$m = 0, \pm 1, \pm 2, \ldots$

index of refraction for plastic : $1 < n < 2$!

(water = 1.33 , glass ~ 1.50)

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- The wave reflected from the bottom surface inside the plastic travels 2d (d=thickness)
- It interferes with the wave that underwent a phase change (top surface reflection).
- The phase difference is then $\pi + \phi$. When this equals an integer multiple of 2π constructive interference occurs.

$$\phi = \frac{2\pi}{\lambda}(2nd)$$

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- $1 + \frac{4nd}{\lambda} = 2m \;\therefore\; \frac{4nd}{\lambda} = 2m-1 \;\therefore\; n = (2m-1)\frac{\lambda}{4d}$

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- $d = \frac{1}{2}\lambda \;(= 250\,\text{nm}) \;\therefore\; n = (2m-1)\frac{1}{2} = m - \frac{1}{2}$

$\therefore$ $m = 2$ is happening and $n = \frac{3}{2}$

Other m-values are rejected, as they would yield n outside of $1 < n < 2$. NB: $d = \frac{1}{2}\lambda$ is rather thin!