Announcements

1. Summary of interference phenomena – comment on HW
2. Topics for today –

   More details about diffraction – single slit diffraction pattern

   Polarization effects of light

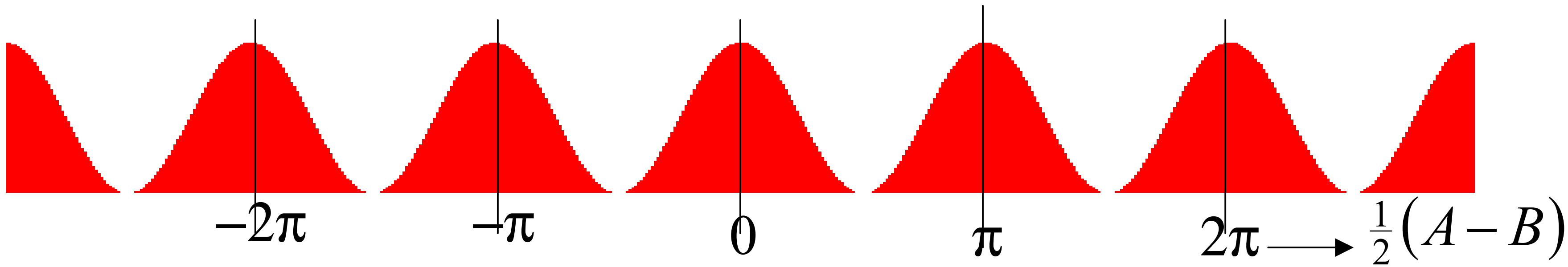
   Summary of electromagnetic waves
3. Next week – “modern” physics -- no online quiz for Monday

Review of interference phenomena – Occurs when there are two or more electromagnetic waves which combine at a give point *P*.

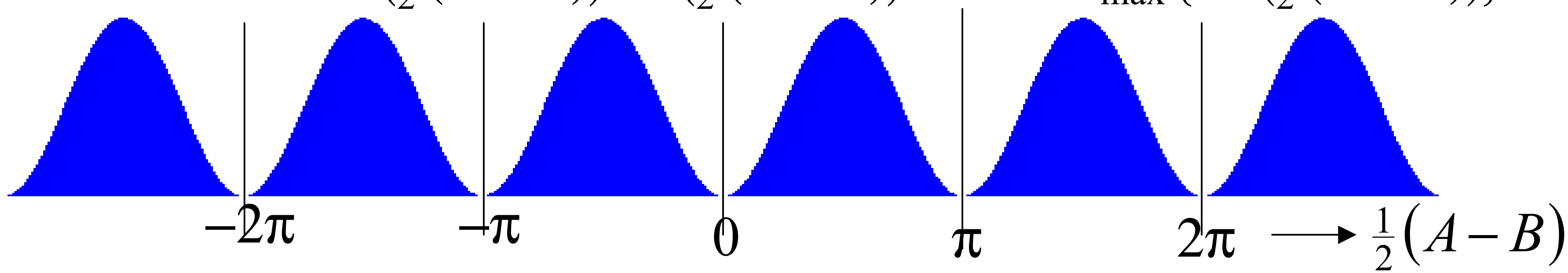
$$E(P,t) = E_{\max}\sin\left(\frac{2\pi r_1}{\lambda} - 2\pi f t\right) \pm E_{\max}\sin\left(\frac{2\pi r_2}{\lambda} - 2\pi f t\right)$$

Trig identity :

$$\sin A + \sin B = 2\sin\left(\tfrac{1}{2}(A+B)\right)\cos\left(\tfrac{1}{2}(A-B)\right) \Rightarrow I = I_{\max}\left\{\cos\left(\tfrac{1}{2}(A-B)\right)\right\}^2$$

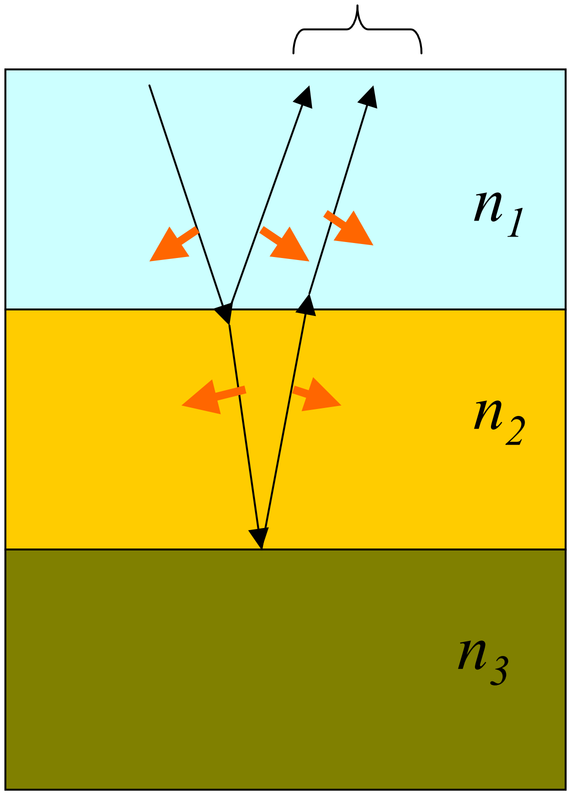


$$\sin A - \sin B = 2\cos\left(\tfrac{1}{2}(A+B)\right)\sin\left(\tfrac{1}{2}(A-B)\right) \Rightarrow I = I_{\max}\left\{\sin\left(\tfrac{1}{2}(A-B)\right)\right\}^2$$



Example of interference with "+"

$n_1 < n_2 < n_3$



For each surface with $n_1 < n_2$

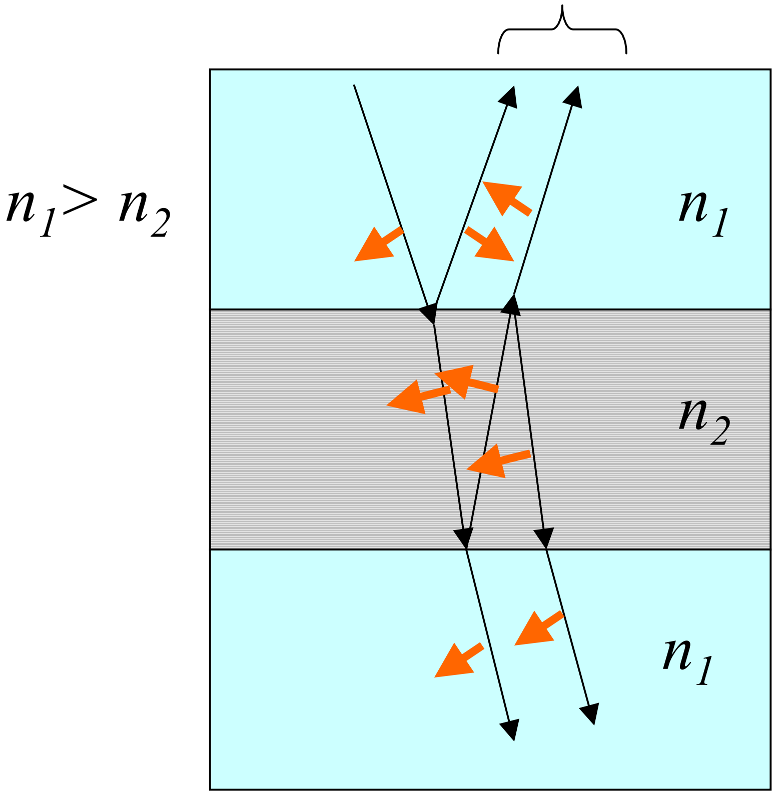
$E_2 = -E_1$ for reflected beam

$$\Rightarrow I = I_{\max}\left\{\cos\left(\tfrac{1}{2}(A-B)\right)\right\}^2$$

peaks at

$$\tfrac{1}{2}(A-B) \equiv \frac{\pi(r_2 - r_1)}{\lambda} = m\pi$$

Example of interference with "–"



$$\Rightarrow I = I_{max}\left\{\sin\left(\tfrac{1}{2}(A-B)\right)\right\}^2$$

peaks at

$$\tfrac{1}{2}(A-B) \equiv \frac{\pi(r_2 - r_1)}{\lambda} = \left(m+\tfrac{1}{2}\right)\pi$$

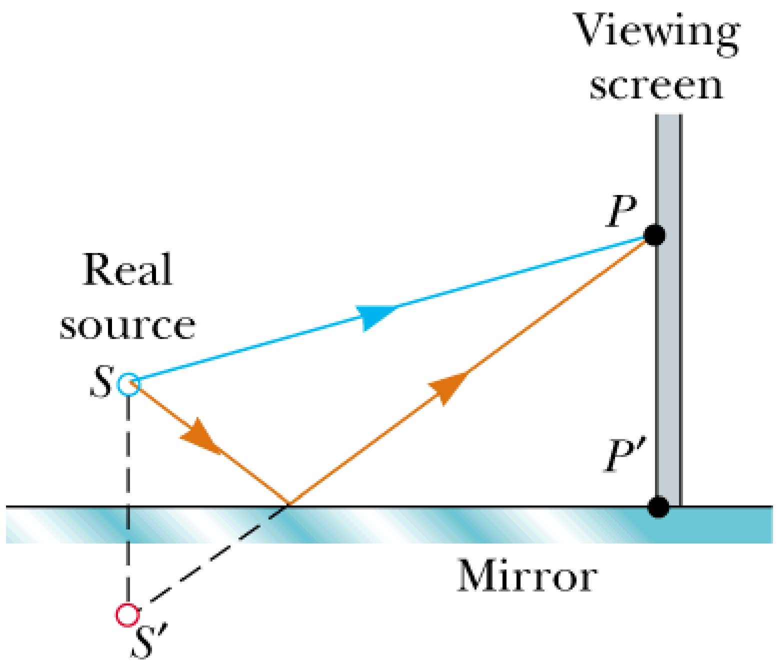
Example of interference with "+"

$$\Rightarrow I = I_{max}\left\{\cos\left(\tfrac{1}{2}(A-B)\right)\right\}^2$$

peaks at

$$\tfrac{1}{2}(A-B) \equiv \frac{\pi(r_2 - r_1)}{\lambda} = m\pi$$

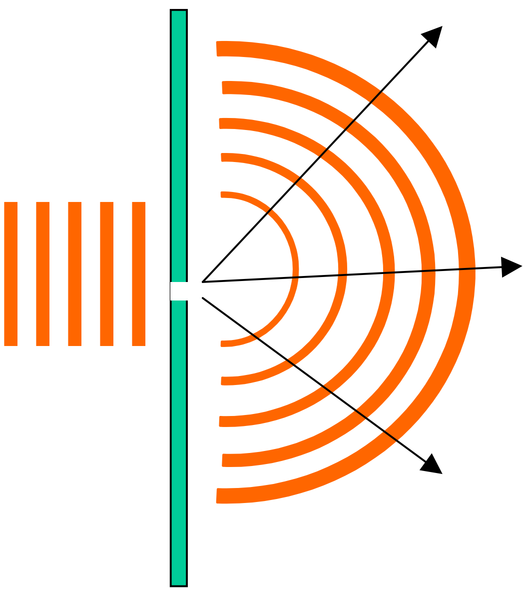
Brief comment on HW # 4



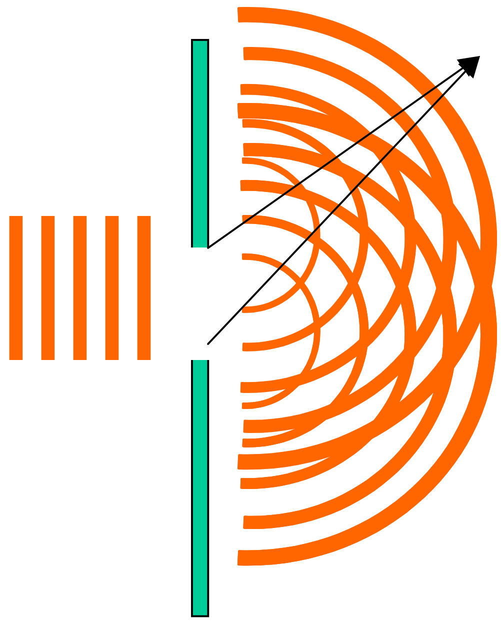
From Fig. 37.14 of your text.

Interference effects within a single slit

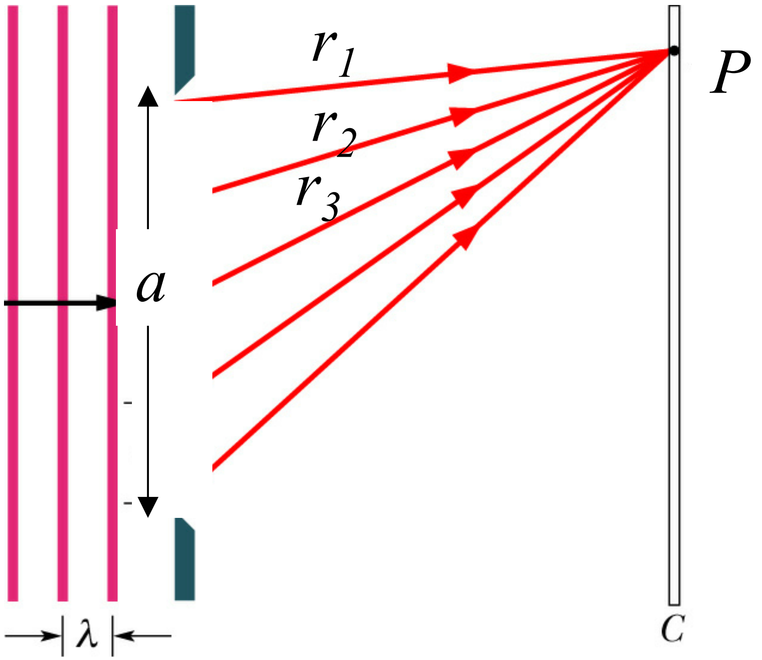
thin slit



thicker slit



Mathematical description of single slit diffraction



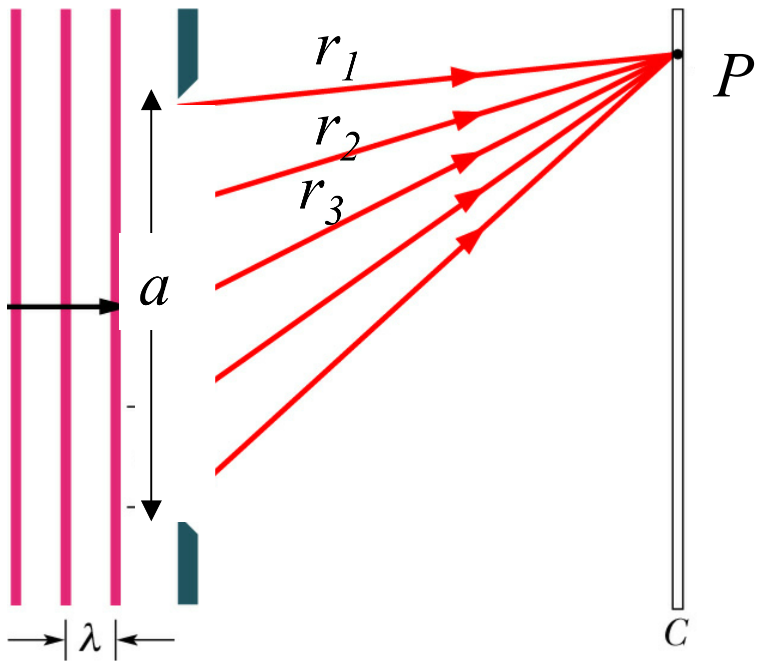
$$E(P,t) = \sum_i E_{\max} \sin\left(\frac{2\pi r_i}{\lambda} - 2\pi f t\right)$$

$$\approx (\text{Constant}) E_{\max} \int_{-a/2}^{a/2} \sin\left(\frac{2\pi(r_{av} - x\sin\theta)}{\lambda} - 2\pi f t\right) dx$$

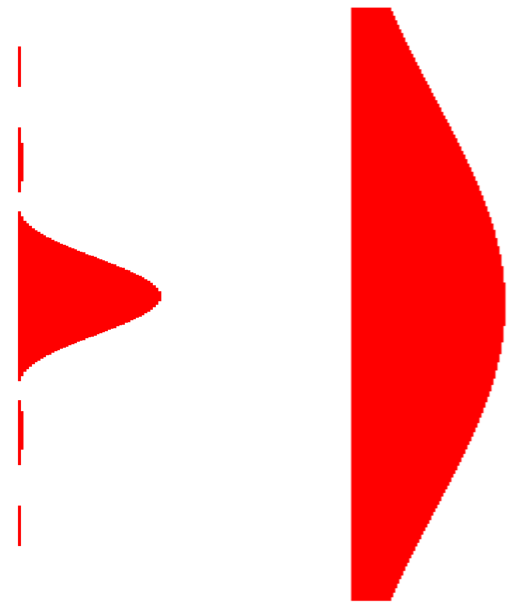
$$= 2(\text{Constant}) E_{\max} \sin\left(\frac{2\pi r_{av}}{\lambda} - 2\pi f t\right) \left\{\frac{\sin\left(\frac{\pi a \sin\theta}{\lambda}\right)}{\left(\frac{\pi a \sin\theta}{\lambda}\right)}\right\}$$

Single slit intensity pattern:

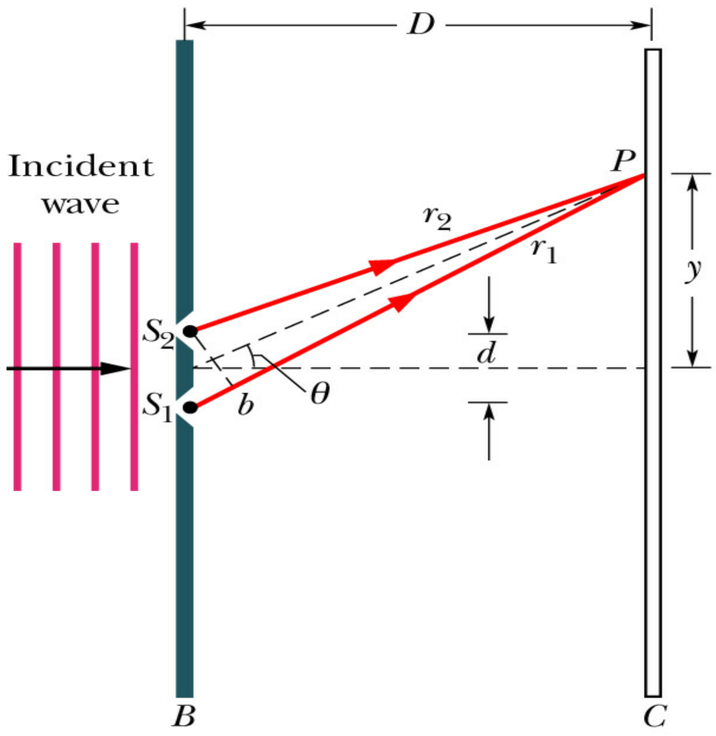
$$\langle I \rangle_{av} = I_{\max} \left\{ \frac{\sin\left(\frac{\pi a \sin\theta}{\lambda}\right)}{\left(\frac{\pi a \sin\theta}{\lambda}\right)} \right\}^2$$

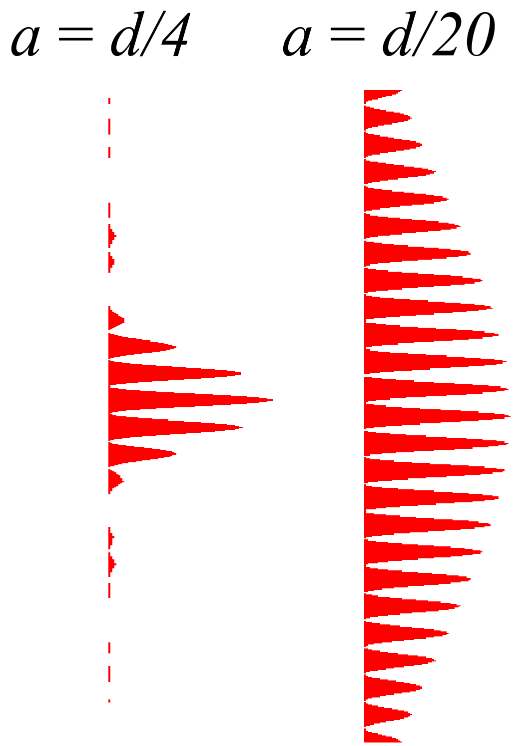


small a smaller a

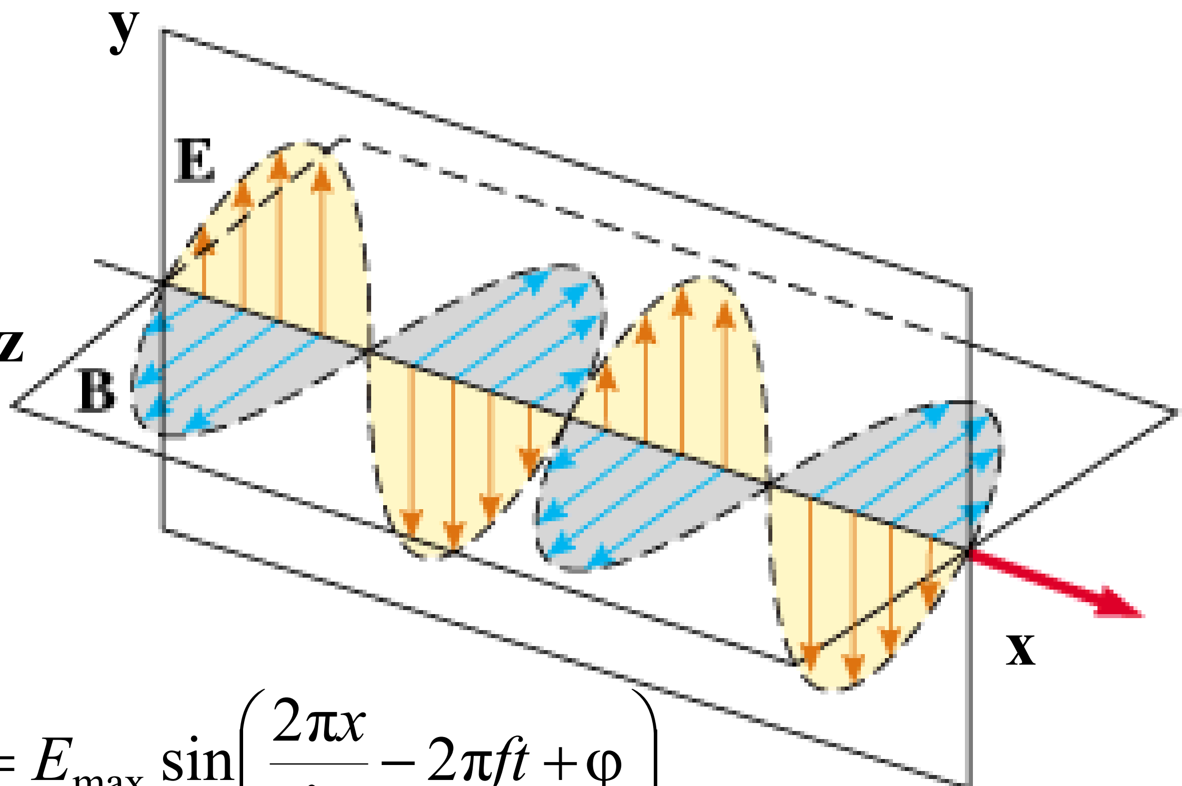


Effect of slit size on double slit pattern





Polarization effects in light



$$E_y(x,t) = E_{\max} \sin\left(\frac{2\pi x}{\lambda} - 2\pi f t + \varphi\right)$$

$$B_z(x,t) = \frac{E_{\max}}{v} \sin\left(\frac{2\pi x}{\lambda} - 2\pi f t + \varphi\right)$$

In this case, E is polarized in y direction

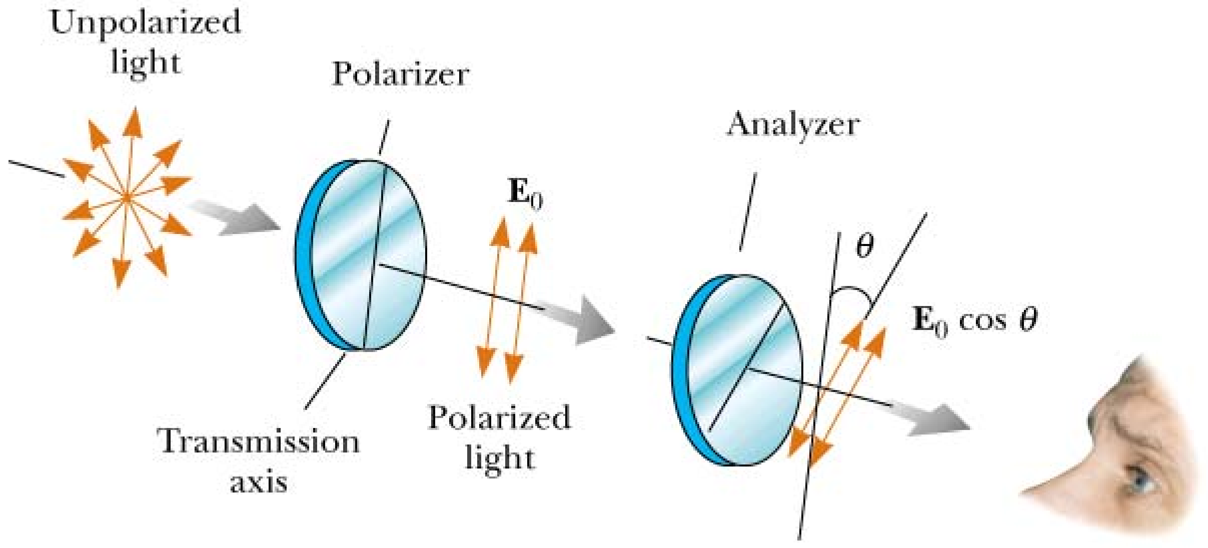
Peer instruction question

Which of the following sources of radiation yield polarized radiation?

(A) Sunlight (B) Light bulb (C) Radio antenna

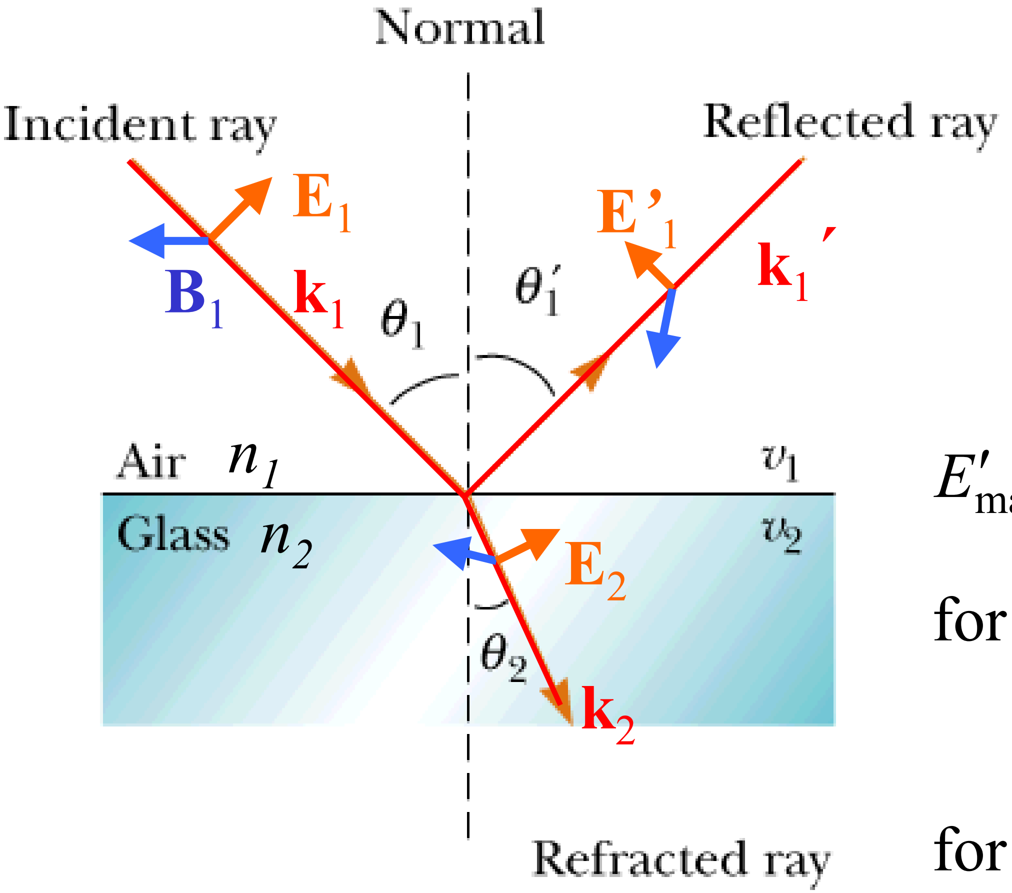
(D) X-rays

Effects of a polarizing filter:



$$I = I_{\max} \cos^2 \theta$$

Plane waves reflected and refracted at surface:



Matching electric and magnetic fields at boundary:

For reflected waves:

$$E'_{\max_1} = E_{\max_1} \frac{n_2 \cos\theta_1 - n_1 \cos\theta_2}{n_2 \cos\theta_1 + n_1 \cos\theta_2}$$

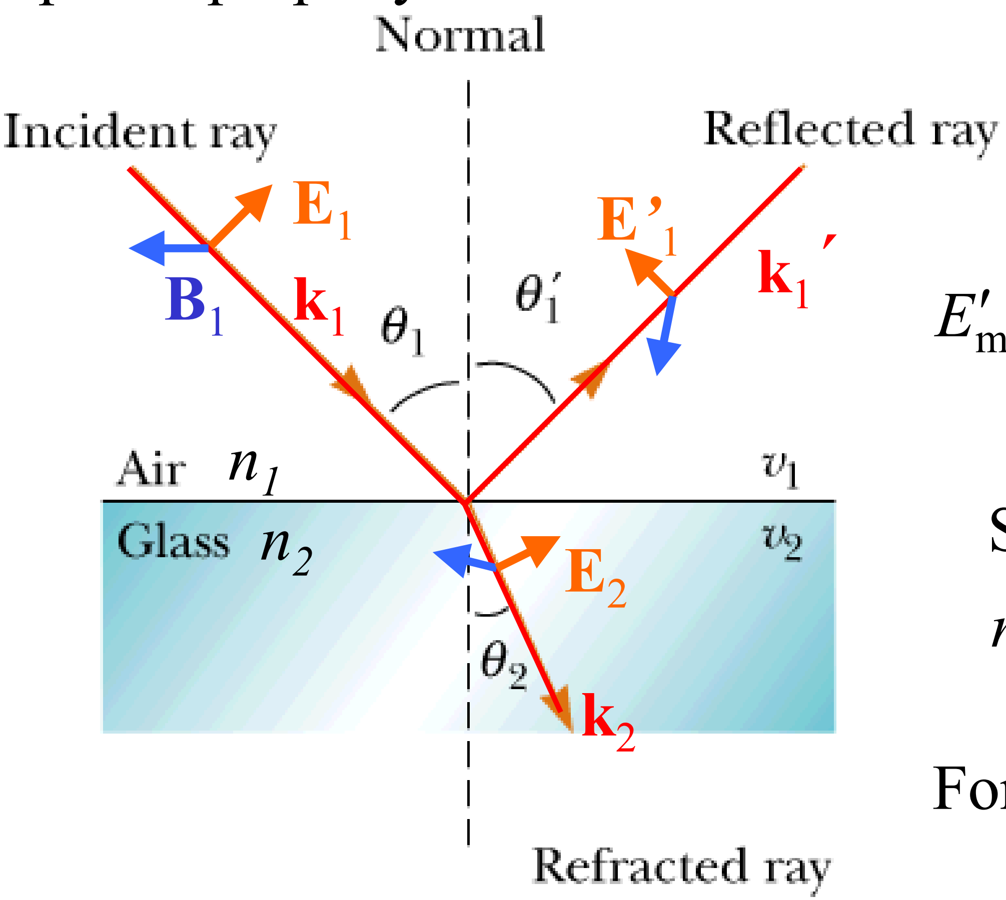
for E in plane of incidence

or

for E out of plane of incidence:

$$E'_{\max_1} = E_{\max_1} \frac{n_2 \cos\theta_2 - n_1 \cos\theta_1}{n_2 \cos\theta_2 + n_1 \cos\theta_1}$$

Special property of reflected wave for E in plane of incidence:



$$E'_{\max_1} = E_{\max_1} \frac{n_2 \cos\theta_1 - n_1 \cos\theta_2}{n_2 \cos\theta_1 + n_1 \cos\theta_2}$$

Snell's law :

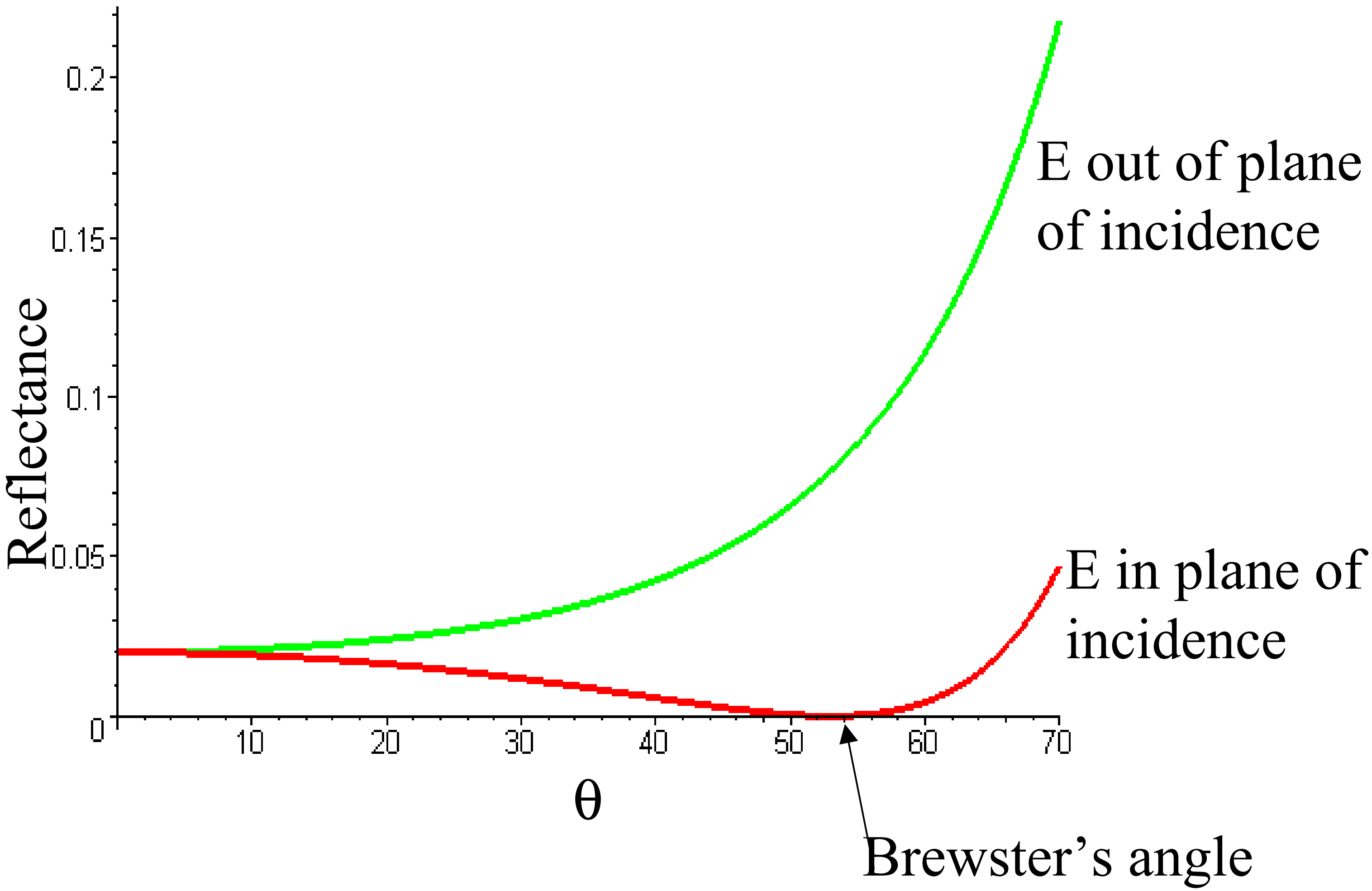
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

For $\theta_1 = \theta_2 = \tan^{-1}(n_2/n_1)$

➔ $E'_{max} = 0$!!

Brewster's angle

Example: $n_1 = 1, n_2 = 1.33$



$\tan^{-1}(n_2/n_1) = 53^o$