Homework 3

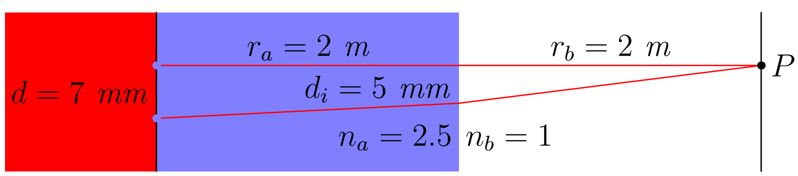
Chapters 24 and 27

Problem 1. *Assume that the intensity of solar radiation incident on the cloudtops of the Earth is* $1370\ W/m^2$. *(a) Calculate the total power radiated by the Sun. (b) Determine the maximum values of the electric and magnetic fields in the sunlight at their source in the photosphere (http://en.wikipedia.org/wiki/Sun#Photosphere) a distance of* $6.96 \cdot 10^8\ m$ *from the center of the sun.*

Problem 2. $11500\ Hz$ *sound waves moving at* $350\ m/s$ *hit a wall with two slits* $50.0\ cm$ *appart. (a) At what angle is the first minimum located? (b) At what angle is the first minimum located if the sound is replaced by* $10.0\ GHz$ *microwaves?*

Problem 3. *Two slits are separated by* $1\ mm$. *A beam of* $440\ nm$ *light incident on the slits produces an interference pattern. (a) Determine the number of intensity maxima observed in the angular range* $-20.0° < \theta < 20.0°$. *(b) If the light is shifted to a longer wavelength, will the number of maxima in that range increase or decrease?*

Problem 4. *A plane wave of monochromatic light moving to the right through a strange material with index of refraction* n_a *hits a barrier with two slits seperated by* d. *Some light passes through each slit, and after moving a distance* r_a *to right, leaves the strange material and enters air with a refractive index* n_b. *The interface bends the light rays according to Snell's law (bending shown on the diagram, so you don't need Snell's law to solve the problem). A distance* r_b *to the right of the interface is a screen, on which an interference pattern appears. The first minimum of the interference pattern appears at point* P, *directly to the right of the top slit. Find the frequency of light.*
HINT. *I've drawn the paths taken to* P *from each slit. The vertical distance between the two rays at the strange-material/air interface is* d_i. *You should use a geometric argument to determine the phase difference between the two paths.*



Problem 5. *An oil film* ($n = 1.5$) *floats on the surface of a bowl of water. The film is illuminated by a white light placed directly above the bowl. Red light at* $\lambda = 650\ nm$ *is the most strongly reflected color. (a) How thick is the oil? (b) What color is most strongly transmitted?*

Problem 6. BONUS PROBLEM. *Derive the Equation 27.8, which gives the average intensity on a screen far from a single slit relative to the maximum intensity* I_{max} *at* $\theta = 0$.

$$I_{avg} = I_{max} \cos^2\left(\frac{\pi d \sin(\theta)}{\lambda}\right) \quad (1)$$

HINT. *Remember from Chapter 24 that for plane waves*

$$I = \frac{1}{2\mu_0 c} E_{max}^2 \quad (2)$$

where the electric field is perpendicular to the direction of propogation. Assume the screen is far enough away that the waves emanating from the slits can be treated as plane waves.