ELEG240- Spring, 2005
Homework 7
Due 4/20, 1 PM

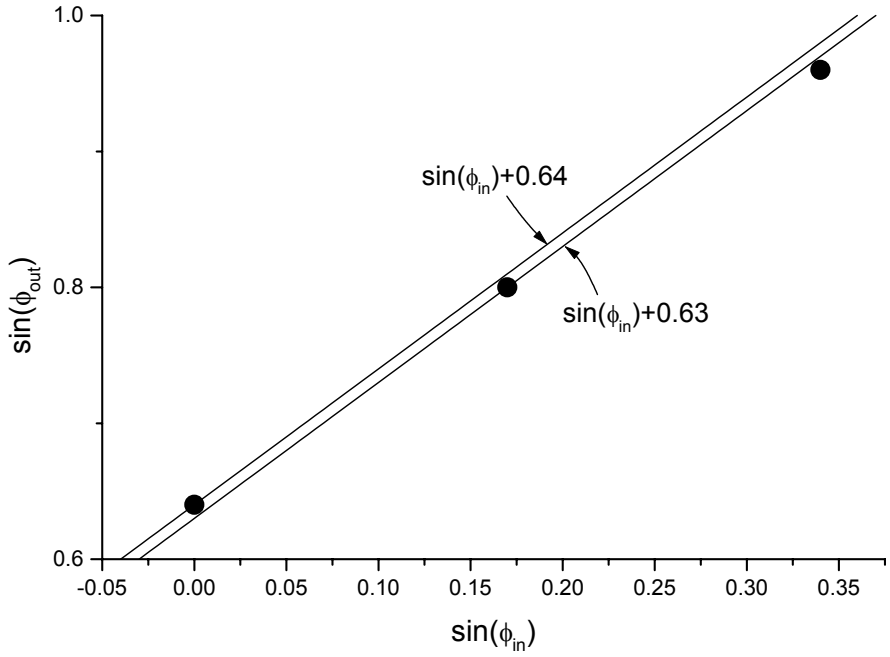
1. So, this is the diffraction lab. I took data on the first diffracted order, and obtained this result, using a laser with a wavelength of 645 nm:

ϕ_{in}	ϕ_{out}
0	40 degrees
10 degrees	53 degrees
20 degrees	74 degrees

What is the period of the grating? Keep in mind that I am not a perfect measurer. I want all the data used to answer the question.
ANSWER:

$\sin\phi_{out} = \sin\phi_{in} + \lambda / a$ for first order.

Thus, it is simplest to plot $\sin\phi_{out}$ vs. $\sin\phi_{in}$:



On sees that the best fit is with $\lambda / a = 0.63$. Thus, a=1020 nm or ~ 1 micron.

2. From the book (Eq. 8.A.21), the Fermi energy of a metal is $E_F = \frac{h^2}{8m}(\frac{3N}{\pi})^{2/3}$.

Show that this has dimensions of energy.
ANSWER:
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$$E_F = \frac{h^2}{8m}\left(\frac{3N}{\pi}\right)^{2/3} = \frac{(\text{joule}\times\text{second})^2}{\text{kilogram}}(1/\text{meter}^3)^{2/3}$$
$$= \frac{\text{joule}^2}{\text{kilogram}(\text{meter}^2/\text{second}^2)} = \frac{\text{joule}^2}{\text{joule}} = \text{joule}$$

3. A metal has a Fermi energy of 7 eV and an electron scattering time of 10^{-14} seconds. It is 1 meter long and has a cross section of 1x1 millimeter. What is its resistance?
ANSWER:

$E_F = \frac{h^2}{8m}\left(\frac{3N}{\pi}\right)^{2/3}$ =7 eV=1.1x10^{-18} joules.

Solve for N=8.5x10^{28} 1/m^3. From Eq. 1.11,

$R = \frac{m\mathrm{L}}{Ne^2\tau\mathrm{S}}$ =0.04 ohms.

4. The work function of gold is 4.3 eV. What is the maximum wavelength light that will cause electrons to emit from gold?
ANSWER:
$E = \frac{hc}{\lambda}$ =4.3 eV=6.9x10^{-19} joules. λ =0.29 microns.

5. What is the chemical formula for magnesium fluoride?
ANSWER:
Since magnesium has 2 valence electrons and fluorine has 7, and a stable compound must have a multiple of 8, MgF_2 is stable.