(1)

If you scratch a row of evenly spaced regular lines into a glass slide, each scratch will scatter all wavelengths of light in all directions. If there are enough lines and they are all separated by exactly the same distance $d$, then you get what is called "diffraction grating" and you see a rainbow of colors. If you have a single white light source shining on the glass slide at an angle $\theta=90.0^\circ$ at infinite distance, and the spacing between the lines is $2 \ \mu m$, at what angle(s) do you see green light ($\lambda=550 \text{ nm}$)? At what angle(s) do you see red light ($\lambda=700\text{nm}$)?

Draw me a picture to illustrate the diffraction of red light.
You have a crystal of butane, \( \text{C}_4\text{H}_4 \), the dimension of the cubic unit cell are 10 x 10 x 10 Å. The coordinates (X,Y,Z) of the carbon atoms are as follows:

- C1: (1.000, 8.000, 3.000)
- C2: (2.000, 7.500, 3.500)
- C3: (3.000, 7.000, 3.000)
- C4: (4.000, 6.500, 3.500)

Find the phase of the reflection \( F \) with Miller indices hkl = 1 2 0 using the Fourier transform. Show your work. Convert Å coordinates (X,Y,Z) to fractional coordinates (x,y,z). Graph the 4 scattering vectors, summed. Assume the scattering factor \( f=6.00 \) for each carbon atom. Here is the Fourier transform:

\[
F(h \ k \ l) = \sum_{r} f(r) e^{2\pi i(hx+ky+lz)}
\]

\[
F(1 \ 2 \ 0) = \text{___________} \text{ (amplitude), ________} \text{ (phase in degrees)}
\]
What is the upper limit coordinate error in Å of a protein crystal structure if the resolution is $d=2.5\text{Å}$ and the R-factor is $R=0.25$? (You may use the Luzzati plot, or you can assume the phase error = $2\pi R/2.3$)