$\theta_{res} = \frac{\lambda}{D}$ θ_{res} smaller = better resolution
smaller λ $\lambda = \frac{hc}{E}$

b) Your ship has 2 different radar sets that you can use to locate airplanes. Which one should you use to get the best resolution? (I.e. which one will let you see 2 airplanes closer together?)

Bigger Photon Wavelength — Bigger Photon Energy

c) Your Compton scattering apparatus can measure scattering angles between 15 and 50 degrees. If an incoming photon of energy 50 keV impinges on a target, scatters from an electron, and is measured by this apparatus, what is the maximum wavelength this scattered photon can have?

I) 0.0297 nm
II) 0.0257 nm
III) 0.0249 nm
IV) 0.0247 nm
V) 0.0239 nm

$\lambda' - \lambda = \lambda_c (1-\cos\theta)$ want this to be big as possible or θ bigger, $\theta = 50$

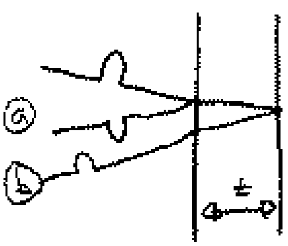
$\lambda = \frac{1240\,eVnm}{50{,}000\,eV} = 0.0248\,nm$

$\lambda' = \lambda + \frac{1240\,eVnm}{511{,}000\,eV}(1-\cos 50°)$

$= 0.0248\,nm + 0.0008668\,nm = 0.0257\,nm$

d) You observe that the light reflected off of a particular location of a soap bubble (n = 1.33) is blue in appearance. Which thickness best describes the bubble thickness at that location. (Assume blue light has λ = 440 nm)

I) 440 nm
II) 331 nm
III) 248 nm
IV) 220 nm
V) 165 nm



get phase of π @ (a)

$\frac{2\pi}{(\lambda/n)}(2t)$ @ (b) → $\frac{2\pi}{(\lambda/n)} 2t = \pi, 3\pi, 5\pi$ or $2t = \left(\frac{\lambda}{n}\right)\left(\frac{1}{2}, \frac{3}{2}, \frac{5}{2}\right)$

$\Delta\phi = \frac{2\pi}{(\lambda/n)}(2t) - \pi = 0, 2\pi, 4\pi$

$t = \left(\frac{440\,nm}{1.33}\right)\left(\frac{1}{4}, \frac{3}{4}, \frac{5}{4}\right) = 82.7\,nm, 248\,nm, 413\,nm$

e) How many orders (maxima) can you see in a diffraction grating where 2000 slits are illuminated by a 500 nm wavelength beam with a transverse size of 1.05 cm? (The beam hits the grating head on.)

I) m=0
II) m=1
III) m=2
IV) m=5
V) m=10

$d\sin\theta = m\lambda$ $\sin_{max} = 1$ $d = \frac{\text{beamsize}}{\#\text{slits}}$

$m = \frac{d\sin\theta}{\lambda} = \frac{d}{\lambda} = \frac{1.05\times10^7\,nm}{500\,nm\,(2000)} = 10.5$

f) If you restrict a photon to have a spatial extent of 0.001 mm, there will be an uncertainty induced in the momentum of the photon, and hence an uncertainty in the energy of the photon. What is this uncertainty?

I) 100 micro-eV
II) 100 milli-eV
III) 1.24 eV
IV) 12.4 MeV
V) 1.24 TeV

$\Delta x \Delta p \geq \frac{h}{4\pi}$ $\Delta E = \Delta pc$

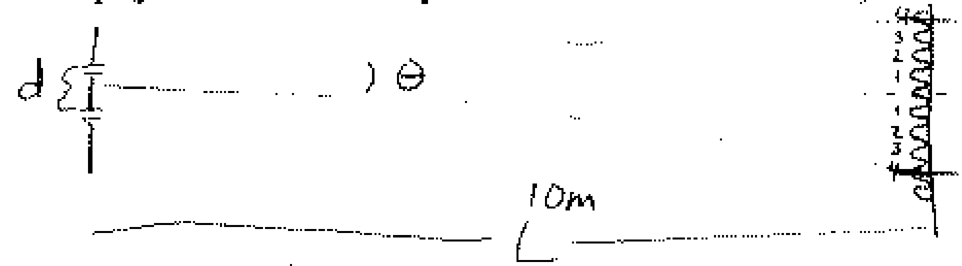
$\Delta pc = \Delta E = \frac{hc}{4\pi\Delta x} = \frac{1240\,eVnm}{4\pi(1000\,nm)}$

$\sim 0.1\,eV$

(Show your work! 8 points each)

3) You are given 2 lasers, an apparatus that measures stopping potential for the photoelectric effect and a double slit. One of the lasers is a red laser and the other laser is a blue laser. You can't move the blue laser, but you can measure the wavelength of the red laser with a double slit that has a separation d = 0.1mm. You find that 9 peaks occur in 50.7 cm on a wall 10m from the double slit. (i.e. the distance between the center of the 1st maxima and the center of the 9th maxima is 50.7 cm) what is the wavelength of the red laser?

Next, your lab assistant finds that the stopping potential for the 2 lasers is 0.56V for one and 1.33V for the other (you should be able to sort out which is which). Please calculate the wavelength of the blue laser and the work function in your photoelectric effect set-up (you'll need to use your answer for the red laser).



50.7cm occupies (8 orders) (4 on each side)
each order corresponds to one m in $d\sin\theta = m\lambda$

$\frac{d\sin\theta}{m} = \lambda$

$\tan\theta = \frac{0.507\,m}{10\,m}$

or $\lambda = \frac{d\sin\left(\tan^{-1}\left(\frac{.507}{10}\right)\right)}{8}$

$\lambda = \frac{10^5\,nm\,\sin\left(\tan^{-1}\left(\frac{.507}{10}\right)\right)}{8}$

$= 632.9\,nm$

now

$eV_1 = \frac{hc}{\lambda_1} - \phi$

$eV_2 = \frac{hc}{\lambda_2} - \phi$

$eV_1 - eV_2 = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$

$\frac{hc}{\lambda_2} = \frac{hc}{\lambda_1} - eV_1 + eV_2$

$\lambda_2 = \frac{hc}{\frac{hc}{\lambda_1} - eV_1 + eV_2}$

$= \frac{1240\,eVnm}{\frac{1240\,eVnm}{632.9\,nm} - 0.56\,eV + 1.33\,eV}$

$\lambda_2 = 454.3\,nm$

$1.33\,eV = \frac{1240\,eVnm}{454.3\,nm} - \phi$

$\phi = 1.4\,eV$

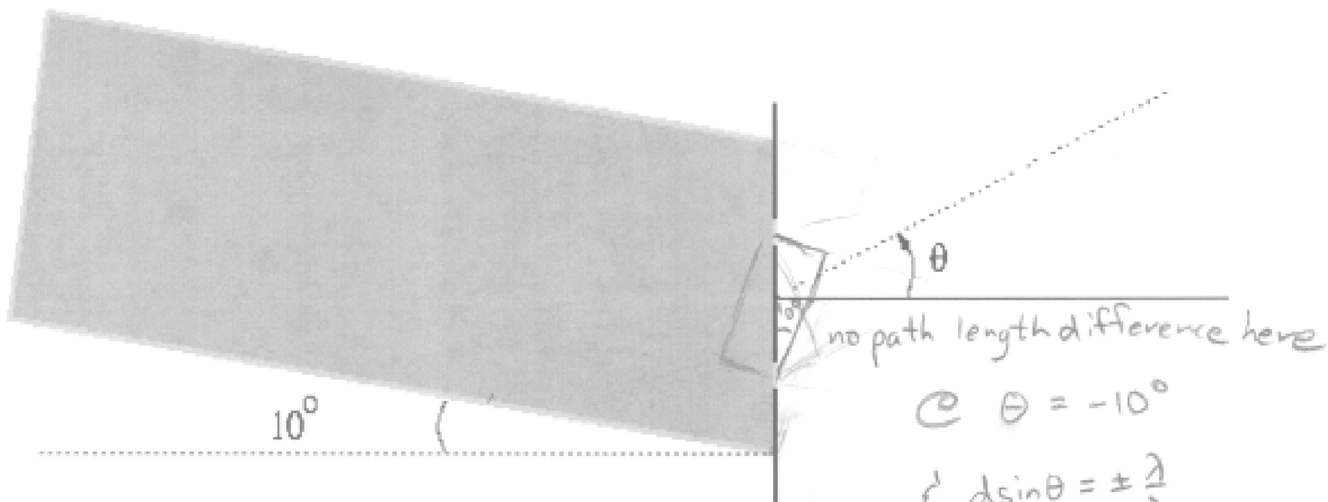
check $\phi = \frac{1240\,eVnm}{632.9\,nm} - 0.56V$

OK!

Red λ = 632.9nm
ϕ = 1.4eV
Blue λ = 454.3nm

(Show your work! 8 points each)

3) 400nm light is incident on two slits as shown in the figure below. Determine the angle at which the brightest maxima (would be at an angle of zero if the light hit straight on) occurs (4 pts). Also, determine the angle at which the first minima on either side of the maxima you found, occur.(4pts)



@ $\theta = -10°$

& $d\sin\theta = \pm\frac{\lambda}{2}$

$\theta = \pm 0.46°$

Other way, start out with

$\delta = d\sin 10°$ path difference

$d = 25\times10^{-6}$ m

$\delta = 4.3\times10^{-6}$ m

$d\sin\theta + \delta = 0$ central maxima

$\sin\theta = -\frac{\delta}{d} = -\sin 10°$ $\theta = -10°$

$d\sin\theta + \delta = \pm\frac{\lambda}{2}$ 1st minima

$\theta = \sin^{-1}\left(\frac{\pm\frac{\lambda}{2} - \delta}{d}\right) = \sin^{-1}\left(\frac{\pm\frac{400nm}{2} - 4341nm}{25{,}000nm}\right)$

$= -10.46°, -9.53$

Brightest Maxima

θ= −10°

Minima on either side

θ=

θ=