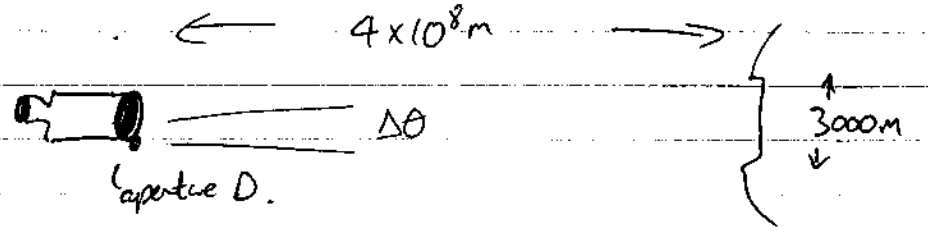
Physics 1C Quiz 3

1. For a 3000m crater at 4×10^8m:

a)



$$\Delta\theta = \frac{3000}{4\times10^8} = 7.5\times10^{-6}\text{ rad}$$

So to resolve this we require $\frac{1.22\lambda}{D} < \Delta\theta$

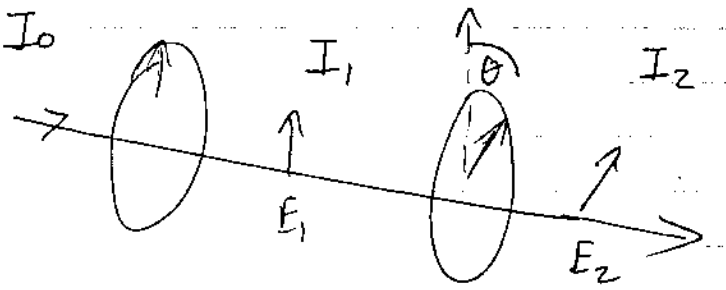
i.e. $D > \frac{1.22\lambda}{\Delta\theta} = \frac{1.22\times500\times10^{-9}\text{m}}{7.5\times10^{-6}} = 8\times10^{-2}\text{m}$

i.e. $\underline{D \geq 81.3\text{mm}}$

b) For 400GHz microwaves, $\lambda = \frac{c}{f} = \frac{3\times10^8\text{m/s}}{400\times10^9\text{Hz}} = 750\mu\text{m}$

So for same $\Delta\theta$, $D > \frac{1.22\lambda}{\Delta\theta} = \frac{1.22c}{\Delta\theta f} = \underline{100\text{m}}$.

2.



For unpolarized light $I_0 = 1000 W/m^2$

after 1st polarizer, irradiance $I_1 = \frac{1}{2} I_0$

∴ after 2nd " $I_2 = I_1 \cos^2\theta = \frac{1}{2} I_0 \cos^2\theta$

So $\cos^2\theta = \frac{2 I_2}{I_0}$. For $I_2 = 375 W/m^2$,

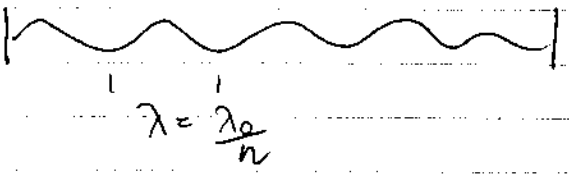
$\cos^2\theta = \frac{3}{4}$

$\Rightarrow \cos\theta = \frac{\sqrt{3}}{2}$ or $\theta = 30°$.

3. Speed of light in medium $v = \frac{c}{n}$

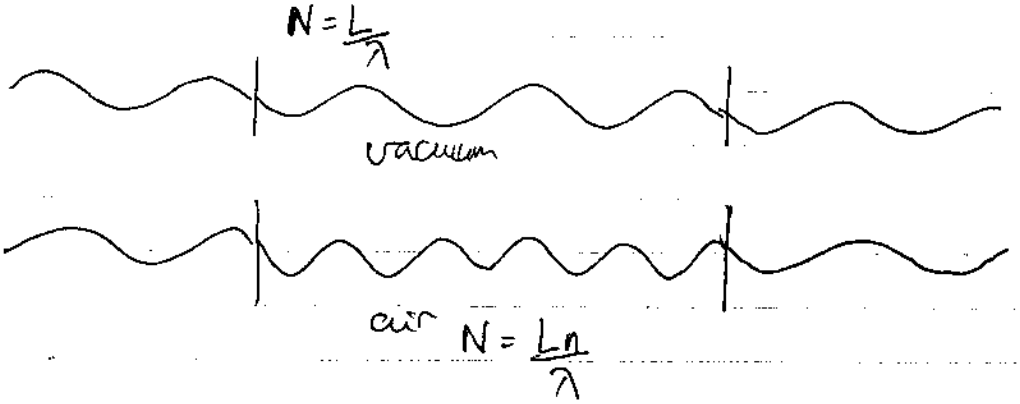
So wavelength in medium $\lambda = \frac{v}{f} = \frac{v}{c}\lambda_0 = \frac{\lambda_0}{n}$

So for a medium length L



# of wavelengths $N = \frac{L}{\lambda} = \frac{L}{(\lambda_0/n)} = \frac{Ln}{\lambda_0}$

b)



For a phase difference of 14.5 cycles

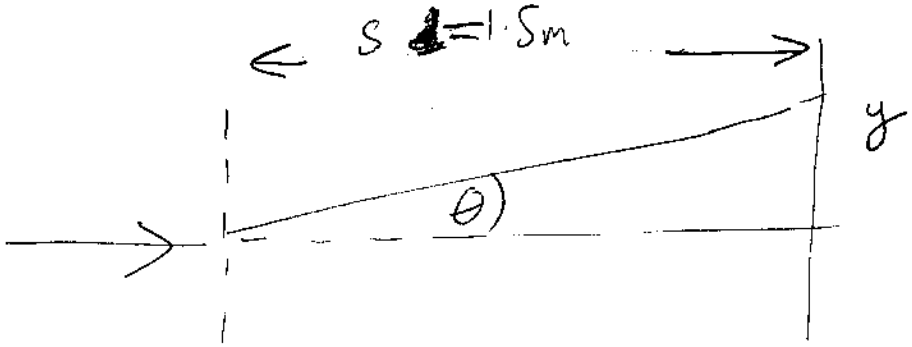
$$\Delta N = N_{vac} - N_{air} = \left| \frac{L \cdot 1.0}{\lambda} - \frac{Ln}{\lambda} \right| = 14.5$$

i.e. $\frac{L}{\lambda}(n-1) = 14.5$

$$\Rightarrow (n-1) = 14.5\frac{\lambda}{L} = 14.5 \times \frac{550\times10^{-9}}{0.02} = 3.98 \times 10^{-4}$$

i.e. $\underline{n = 1.000398}$ for air

4.



$\sin\theta_m = \frac{m\lambda}{a}$ $\quad \lambda = 486\text{nm}$, $a = 2400\text{nm}$

a) $\sin\theta_m = 0.2025\,m$

So for $|\sin\theta_m| \leq 1$, $0.2025|m| \leq 1$

or $|m| \leq 4.93$

So $m = 0, \pm1, \pm2, \pm3, \pm4$.

4th order is highest.

b) For $m = \pm1$, $\sin\theta = 0.2025 \Rightarrow \theta = 11.68°$

c) Position on wall $y = s\tan\theta \approx s\sin\theta = \frac{sm\lambda}{a}$

distance $s = 1.5\text{m}$

$= 1.5\tan 11.68° \approx \frac{1.5 \times 1 \times 486}{2400}$

$= \underline{0.310\,m} \approx \underline{0.30375\,m}$