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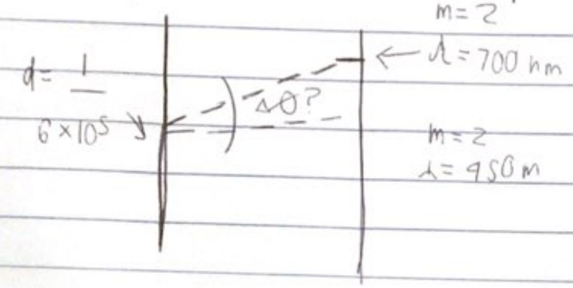
PHYSICS 5B - MIDTERM 2

1. I will calculate angular spread by calculating the difference in diffraction angles for the red and blue light produced with the equation $d\sin\theta = m\lambda$



$700\text{ nm} \times \frac{1\text{ m}}{10^9\text{ nm}} = 7\times10^{-7}\text{ m}$

$d\sin\theta = m\lambda$

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

$450\text{ nm} \times \frac{1\text{ m}}{10^9\text{ nm}} = 4.5\times10^{-7}\text{ m}$

$\rightarrow d = \frac{1}{6\times10^5}$

$\theta = \arcsin\left(\frac{m\lambda}{d}\right) = \arcsin\left(\frac{2\times7\times10^{-7}}{\frac{1}{6\times10^5}}\right) = \arcsin(0.84)$

$\theta = 57.1°$

$\theta = \arcsin\left(\frac{2\times4.5\times10^{-7}}{\frac{1}{6\times10^5}}\right) = \arcsin(0.54)$

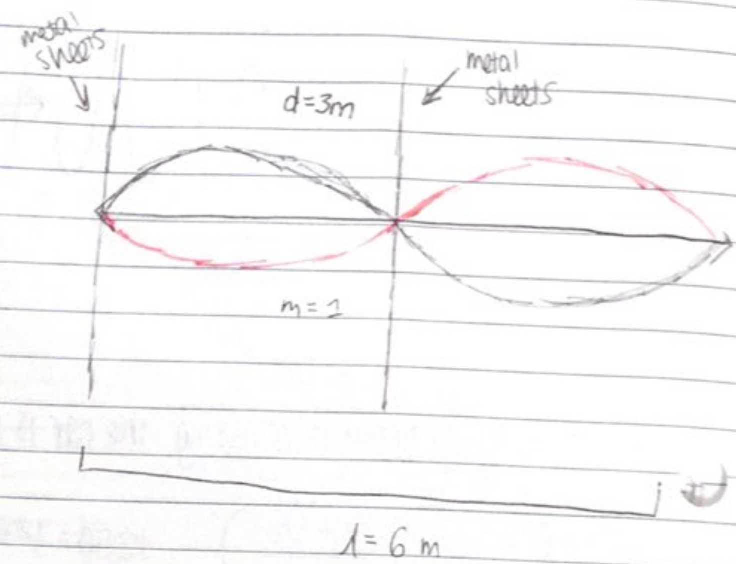
$\theta = 32.7°$

$57.1 - 32.7 = 24.4° = \Delta\theta$

* There is an angular spread of 24.4°

3

· I will use the known wavelength and speed of light to calculate the frequency of the radio waves



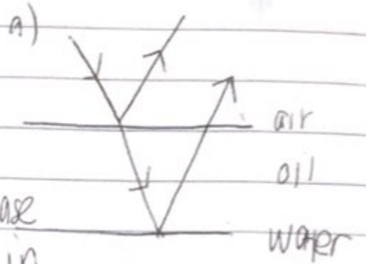
$c = \lambda v$

$v = \frac{c}{\lambda}$

$v = \frac{3\times10^8}{(3)(2)} = 5\times10^7 s^{-1} = 5\times10^7 Hz = f$

The frequency is 5×10^7 Hz for d=3 between the two metal sheets.

4



a) To find the most strongly reflected light, I want to make the inverted wave in phase by adding a wavelength of 1/2 to the out-of-phase wave. Then, I will see what wavelengths fall in the visible light range

· constructive interference + $\frac{1}{2}$ wavelength

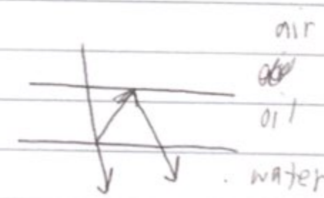
$$2t = m\frac{\lambda}{n} + \frac{1}{2}\frac{\lambda}{n}$$

~~5803 = m λ/n + 1/2 λ/n~~

$$2t = \frac{\lambda}{n}\left(m + \frac{1}{2}\right)$$

$$\frac{2tn}{m+\frac{1}{2}} = \lambda$$

· possible m values	wavelength (λ)
0	1624 nm
☆ 1	541 nm
2	324 nm
3	232 nm



· visible light = ~~380~~ → 700
380 nm → 700 nm

* The wavelength of 541 nm is most strongly reflected, corresponding to green.

b. I will find the transmitted waves in phase (i.e. constructive interference), and choose the wavelength in the visible light spectrum.

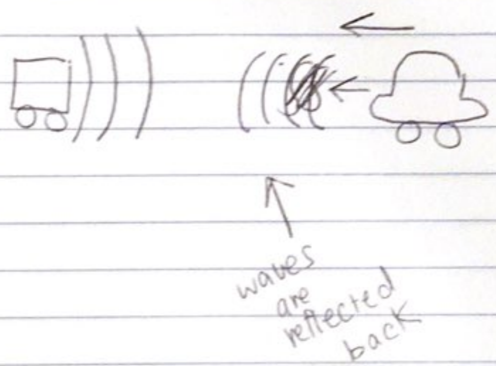
$$2t = m\frac{\lambda}{n} \rightarrow \frac{2tn}{m} = \lambda$$

· possible m values	wavelength (λ)
0	n/a
1	812 nm
☆ 2	406 nm
3	271 nm

* The wavelength of 406 nm is most strongly transmitted, corresponding to violet.

3. To calculate the v_o value, I have to consider that there are two Doppler shifts occuring, first where the object is the observer and then the Doppler effect of the moving car reflecting the sound, where $v_o = 0$ and v_s is decreasing.

a) Since the frequency is increasing, the car is moving towards the police car.



b)

$$f_{obs} = f\left(\frac{V+V_o}{V}\right)\left(\frac{V}{V \pm V_o}\right)$$

$$1250 = 1220\left(\frac{343+V_o}{343}\right)\left(\frac{343}{343 \pm V_o}\right)$$

$$\frac{1250}{1220} = \left(\frac{343+V_o}{343}\right)\left(\frac{343}{343 \pm V_o}\right)$$

$$\frac{1250}{1220} = \frac{343+V_o}{343-V_o}$$

$$1250(343-V_o) = 1220(343+V_o)$$

$$428750 - 1250V_o = 418460 + 1220V_o$$

$$10290 = 2470\,V_o$$

$$V_o = 4.17\ m/s$$

The observer is moving at 4.17 m/s towards the police car.