Phy 202
Charles Cunningham

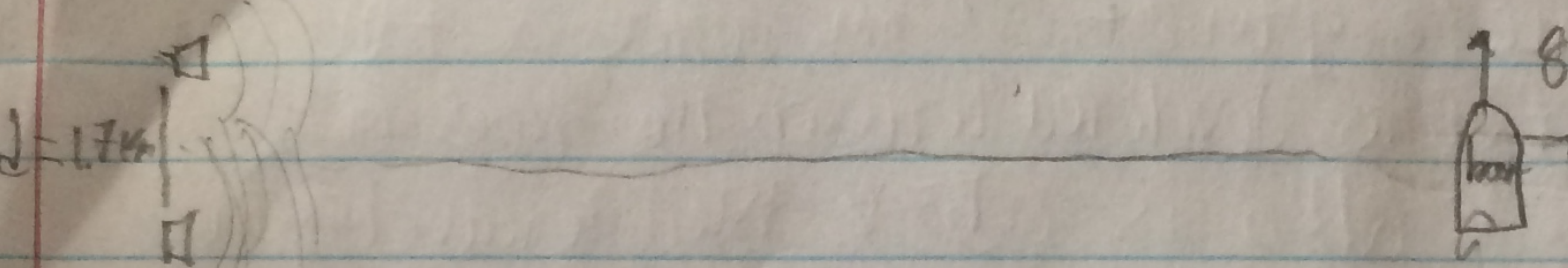
HW for

Q3R.1, Q4M.2

1

Q3R.1

You are at sea on a foggy night. You are trying to find out how far you are from shore, but fog is too thick. After a certain time, you finally hear two separate foghorns on your left side, perpendicular to your direction of travel. Each foghorn emits a short blast of sound at a pitch of 200 Hz every 2.00 s exactly. The foghorns are 1.7 km apart. At a certain time, you notice that you hear the blasts from the horns simultaneously. After having sailed for 22 min at 8.8 km/h, you hear the foghorns exactly out of phase. Roughly how far are you from the foghorns now?



$8.8\frac{km}{h} = 8.8\frac{km}{h} \cdot \frac{1000m}{1km} \cdot \frac{1hr}{3600s}$

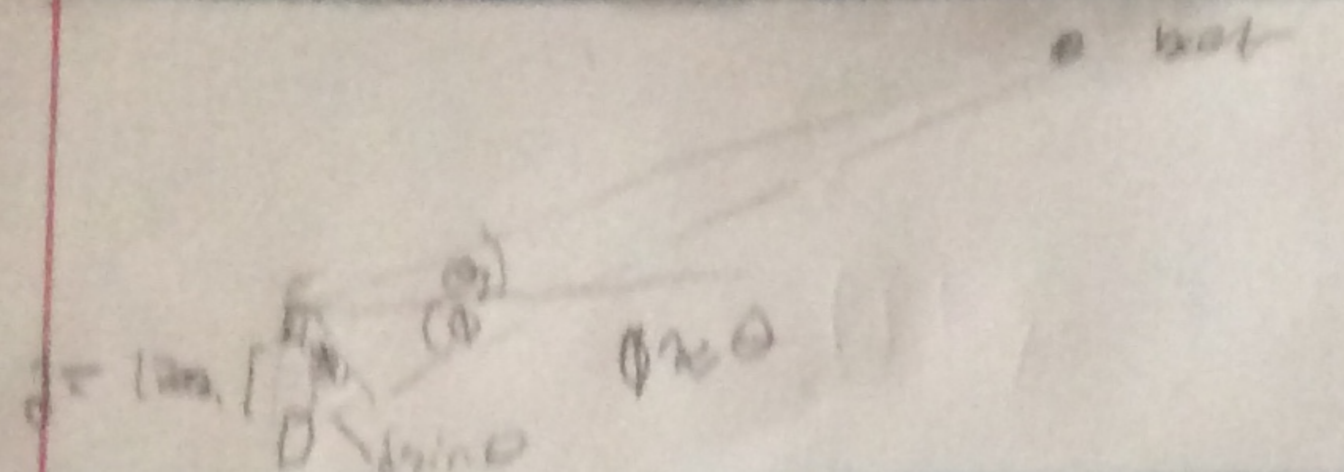
$\Rightarrow 2.4 m/s$

I.

We can assume that we are far enough away from the foghorns that the small angle approximation will apply here.

Initially, each foghorn sounds about as loud as the other, so we can assume that they are the same distance from the boat initially. Modelling the situation as diffracted waves interfering with each other, this means that the difference in path length, ($d \cdot \sin\phi = n\lambda$) is zero (initially).

After $t = 22min \cdot \frac{60s}{min} = 1320s$, at $|\vec{v}| = 2.4 m/s$, we have travelled 3226 m.
We now hear the foghorns completely out of phase. If we model the foghorn blasts as "waves," then their wavelengths should be
$\lambda = \frac{343 m/s}{2.00s} = 171.5m$. For interfering diffracting waves, the difference in path length is $(n+\frac{1}{2}) \cdot \lambda = d\sin\phi$. Assuming that this is the first time we hear the foghorns out of phase, then $n=0$. So we get $\frac{1}{2}\lambda = d \cdot \sin\phi \Rightarrow \sin\phi = \frac{\frac{1}{2}\lambda}{d}$



The distance between the boat and the foghorns at this point is
$D = \frac{3326m}{\sin\theta_1}$ where θ_1 is the angle between the line perpendicular to our direction of travel and the line connecting the boat to the foghorns.
Because $D \gg d$, we can say that $\theta_1 \approx \phi$, so $\sin\theta_1 \approx \sin\phi = \frac{3\lambda}{d}$

$$\text{So } D = \frac{3326m}{\left(\frac{3\lambda}{d}\right)} = \frac{3326m}{\left(\frac{3\cdot 17.1.5m}{1400m}\right)} \approx 63968m \approx 64km$$

Q4M.2
When we illuminate cesium metal with monochromatic light with a wavelength of 500 nm, suppose we find that the maximum potential difference developed between the plates in the experimental setup shown in Q4.6 is 0.57V. When the wavelength is 420nm, we find this voltage to be 1.04V. Check that the experimental results are consistent with a value of 1240eV·nm for hc (within ±1%) and find the value of W for cesium.

A maximum potential difference of V_1 in the experimental setup represents the maximum kinetic energy of the electron, K_1(eV) which has the same numerical value as V_1.

From equation Q4.7, we have $K = \frac{hc}{\lambda} - W \Rightarrow W = \frac{hc}{\lambda} - K$
Let $K_1 = 0.57eV$, $K_2 = 1.04eV$, $\lambda_1 = 500nm$, $\lambda_2 = 420nm$
So we get $\frac{hc}{\lambda_1} - K_1 = \frac{hc}{\lambda_2} - K_2 \Rightarrow K_2 - K_1 = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_1}$
$\Rightarrow \frac{K_2 - K_1}{\left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1}\right)} = hc \Rightarrow hc = \frac{1.04eV - 0.57eV}{\frac{1}{420nm} - \frac{1}{500nm}} = \frac{0.47eV\cdot nm}{(420)^{-1} - (500)^{-1}} = 1234\,eV\cdot nm$

We should get a value of 1240eVnm ± 1%, $1240eV\cdot nm \cdot \frac{1}{1.01} \approx 1228eV\cdot nm$
So the experimental value is consistent with the theoretical value.

Calculating W: $W = \frac{1234eV\cdot nm}{420nm} - 1.04eV = \boxed{1.9eV}$

Eval of answers:

Q3.2.1

Magnitudes seem reasonable, correct units

Q4.1.2

Magnitudes seem reasonable, correct units