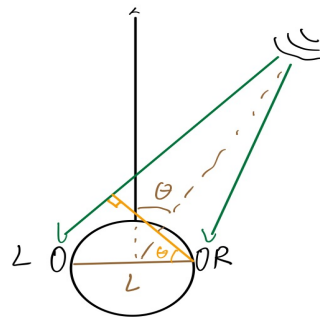


R1.1

- Derive Interaural Time Difference



(ITD)

it takes longer time to reach left ear than right ear.

the difference is roughly
 $L \cdot \sin \theta$ (assumes
 source is far away)

The difference in hearing
 time is Δt

$$\text{so } L \cdot \sin \theta = \Delta t \cdot c$$

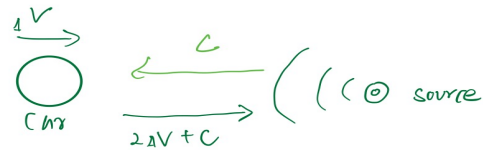
$$\sin \theta = \frac{\Delta t \cdot c}{L}$$

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R1.2

- Derive Doppler effect

Derive $\Delta f = \frac{2\Delta V}{c} f_0$



for moving object, $\tau_0 = \frac{1}{f_0}$, for one time interval τ_0 , the wave moves $\lambda' = \lambda - \Delta V \cdot \tau_0$

$$\begin{array}{ll} \text{source} & \text{reflected} \\ f_0 = \frac{1}{\lambda_0} V_0 & f_r = \frac{V_0}{\lambda_s} = \frac{V_0}{\lambda - 2\Delta V \cdot \frac{1}{f_0}} \end{array}$$

$$V_0 = c$$

$$\Delta f = f_r - f_0 = \frac{2\Delta V}{\lambda_0} = 2 \frac{\Delta V}{c} f_0$$

•

R1.3

- To better measure the angle, we need to choose signal with larger wavelength so the Δt is easier to find.

R1.4

- To better measure the speed of a moving object, we need to choose signal with high frequency so for the same velocity the measured Δf is larger.

R2.1

- It depends on the data buffer available, we can do window fft but it is not able to extract low frequency components from it since the data window buffer length is limited.

R2.2

- We can use FFT to see what frequency components does the signal contains and find the dominant frequency.

R3.1

- If there is no memory buffer available, pure online data streaming, there is no way to implement the cross-correlation since it requires also some past signals data.

R3.2

- To use cross-correlation, we need to have a buffer to save part of the past data. In this way it is possible to identify a delay within certain range.