SAN DIEGO MESA COLLEGE
PHYSICS 197 LAB REPORT

Name:________________________________
Date:______________ Time:___________
Partners:____________________________
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TITLE: Doppler Effect

Objective:

To investigate the Doppler Effect using the beats phenomenon.

To find f' using beat frequency.

To find f' using the Doppler equation.

Theory:

Why does the pitch of an approaching car's horn or siren change as it passes by? In this experiment, we will explore and explain this phenomenon using the concept of the Doppler effect. As discovered by Austrian physicist Christian Doppler in 1842, if a wave source and a receiver are moving relative to each other, the received frequency is not the same as the frequency of the source. The received frequency is less than the source frequency when the objects are moving away from each other, and is greater than the source frequency when the objects are moving toward each other.

In order to calculate what the perceived frequency (f' or f_r) of the wave as it reaches the receiver, we use the following equation:

$$f_r = \frac{v \pm u_r}{v \mp u_s} f_s$$

which can be rearranged into

$$f_r = \frac{1 \pm \frac{u_r}{v}}{1 \mp \frac{u_s}{v}} f_s$$

where f_r is perceived frequency, f_s is source frequency, u_r is the speed of the receiver, u_s is the speed of the source, and v is the speed of sound in the medium (in this experiment, it will be the speed of sound in air). When the source and receiver are moving *toward* each other, the sign in the numerator is positive and the sign in the denominator is negative. When the source and receiver move *away* from each other, the sign in the numerator is negative and the sign in the denominator is positive.

Another concept explored in this experiment is the phenomenon of beats. When two sound waves with slightly different frequencies are out of phase, a tone with a frequency equal to the difference between the frequencies of the two sources will be observed. This is known as beats, and its frequency f_b can be expressed in the following equation:

$$f_{beat} = \Delta f = |f_2 - f_1|$$

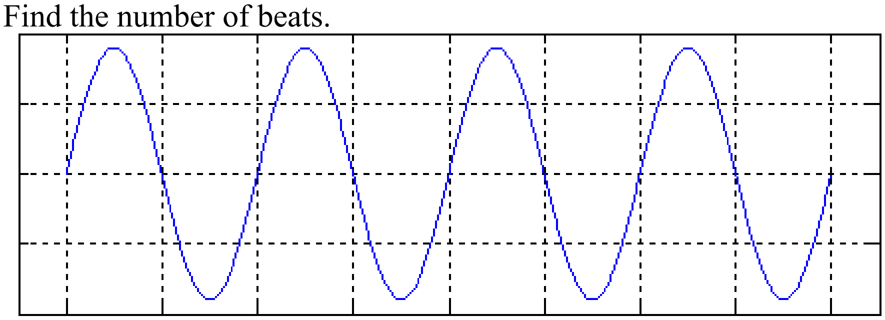
where f_2 and f_1 are the frequencies of the original two sources.

In our "virtual experiment" (based on video produced by *Films for the Sciences and Humanities* in 1987), sound was generated by an oscillator and a parabolic reflector was used to focus the sound waves to be detected by a receiver. The receiver was connected to an oscilloscope, which was then used to plot the beat frequencies that were observed when the received frequency interfered with the frequency that was generated by the oscillator.

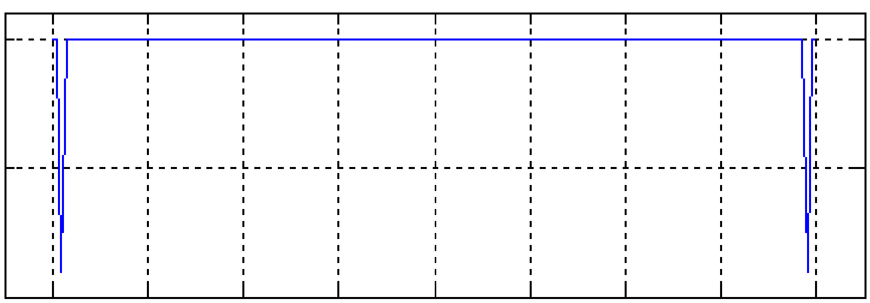
Pre Lab:

Use the figures to answer the following questions before starting the lab.

a) Find the number of beats.

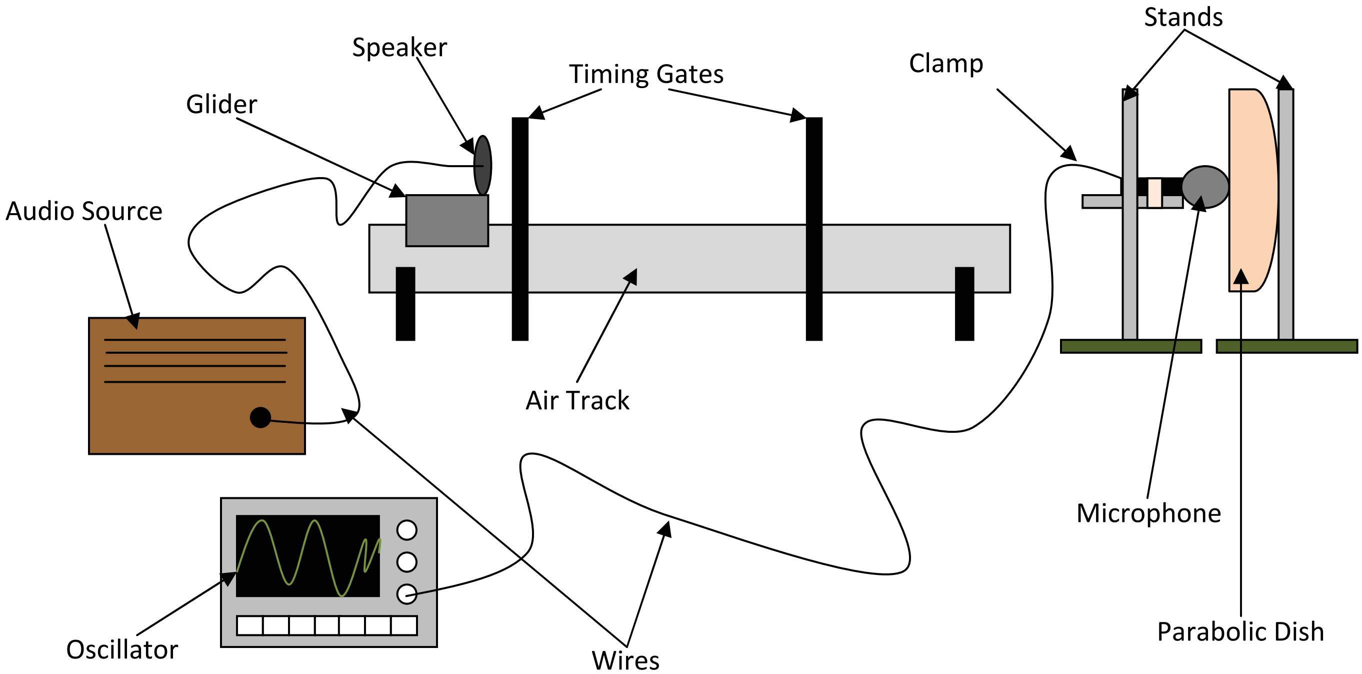


b) Find the distance between the two blips assuming each square equals 1 cm.



c) Find f_{beats} , assuming that 1 cm = 4s.

Setup:



Equipment:

Air Track	Speaker	Wire (2)
Parabolic Dish	Microphone	Cart
Stand (2)	Oscillator	Clamp
Tape	Audio Source	Timing Gates

Experiment on the Doppler Effect (VHS Video tape)

Procedure:

In the experiment, a smooth air track was set up along a table with a receiving microphone and parabolic reflector at one end. A timing gate was also set up along the track. A small cart with an oscillator attached was set on the track. The oscillator was turned on and allowed to emit sound at a constant pitch. The cart was then pushed across the air track at a constant speed. As the cart moved towards the receiver, the frequency received differed from the frequency emitted by the oscillator(received frequency was higher than emitted frequency as the source moved *towards* the receiver).The receiving microphone started to collect data when the cart passed the first gate and finished when the cart passed the second gate. The resulting beat frequency was then plotted with an oscilloscope, as well as the time that passed between the start and finish of the data collection. This was done for four trials with the cart moving at different increasing speeds.

Data:

Complete to following data tables.

Sample data table:

Frequency of Beats Observed			
Trial	Number of beats observed	Number of squares covered	Graphing unit scaling
5	4	8	4 seconds/square
Sound signal from oscillator: 1.486kHz			

Data Table 1

Frequency emitted by oscillator	
Distance Traveled from start to finish on the air track	
Air Temperature	

Data Table 2

Table 1: Frequency of Beats Observed			
Trial	Number of beats observed	Number of squares covered	Graphing unit scaling
1			
2			
3			
4			

Analysis:

Using the data you recorded to answer the following questions.

1. Find the velocity of sound (ν_{sound}) in air.
   a. Using the equation $v_{sound} = c + 0.6\,(T\,°C)$. Where c is the speed of sound at 0°C.

b. Using the equation $v_{sound} = \left(\frac{\gamma KT}{M}\right)^{\frac{1}{2}}$. Where γ is the adiabatic index or heat capacity ratio, K is the ideal gas constant, T is temperature in Kelvin, and M is the mean molar mass. List the source where you found your values.

c. Compare your answers from parts (a) and (b) by finding the percent error.
(Note: It doesn't matter which value you let be ν_{sound} actual and ν_{sound} experimental.)

2. Find the time of each trial.
   a. Trial 1

   b. Trial 2

c. Trial 3

d. Trial 4

3. Find the beat frequency (f_{beats}) for each trial.
   a. Trial 1

   b. Trial 2

   c. Trial 3

d. Trial 4

4. Find the velocity of the source (u_{source}) for each trial.
   a. Trial 1

   b. Trial 2

   c. Trial 3

   d. Trial 4

5. Find the perceived frequency for each trial using the beat frequency.
    a. Trial 1

    b. Trial 2

    c. Trial 3

    d. Trial 4

6. Find the Perceived frequency for each trial using the Doppler equation.
    a. Trial 1

    b. Trial 2

c. Trial 3

d. Trial 4

7. Compare f' from part (a) and (b) by finding the percent error for each trial.
   a. Trial 1

   b. Trial 2

   c. Trial 3

   d. Trial 4

Summary of Results:

Summarize your results in a table.

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Works Cited

Experiments on the Doppler Effect. Films for the Sciences and Humanities, 1987. Videorecording.Tipler, Paul A., Gene Mosca. *Physics: For Scientists and Engineers*. 6th ed. New York: W. H. Freeman and Company, 2008. 498-499.