Research Question

"Can we create Vortex Patterns in a Plasma Gas used in Space flight?"

This experiment will investigate whether or not a vortex formation can be induced by sound in Sulfur Hexa flouride and Xenon in seperate experiments. Sulfur Hexa flouride will be used as an affordable pre-plasma testing medium in which we can be tested with a prefabricated JHM chamber which will be developed as part of this experiment. Will the gas react to sound waves in a similar manner as lycopodium powder? Observing and recording measurements during experimentation will allow for theoretical predictions of vortex shape and size for our Xenon plasma.

~~During~~ The purpose of creating a vortex in a propellant gas such as xenon is to achieve new means of converting stored electrical power on a space flight vehicle into propulsion velocity.

Methods

Part I Create lab environment for Sound Experimentation

For this experimentation, a modular testing environment will be designed and constructed which will allow us to test different mediums with Simple Harmonic Motion. This environment will consist of a pressurized chamber, which will be connected to a harmonic driver or series of harmonic drivers. This modular testing environment will allow for testing of multiple experiments including:

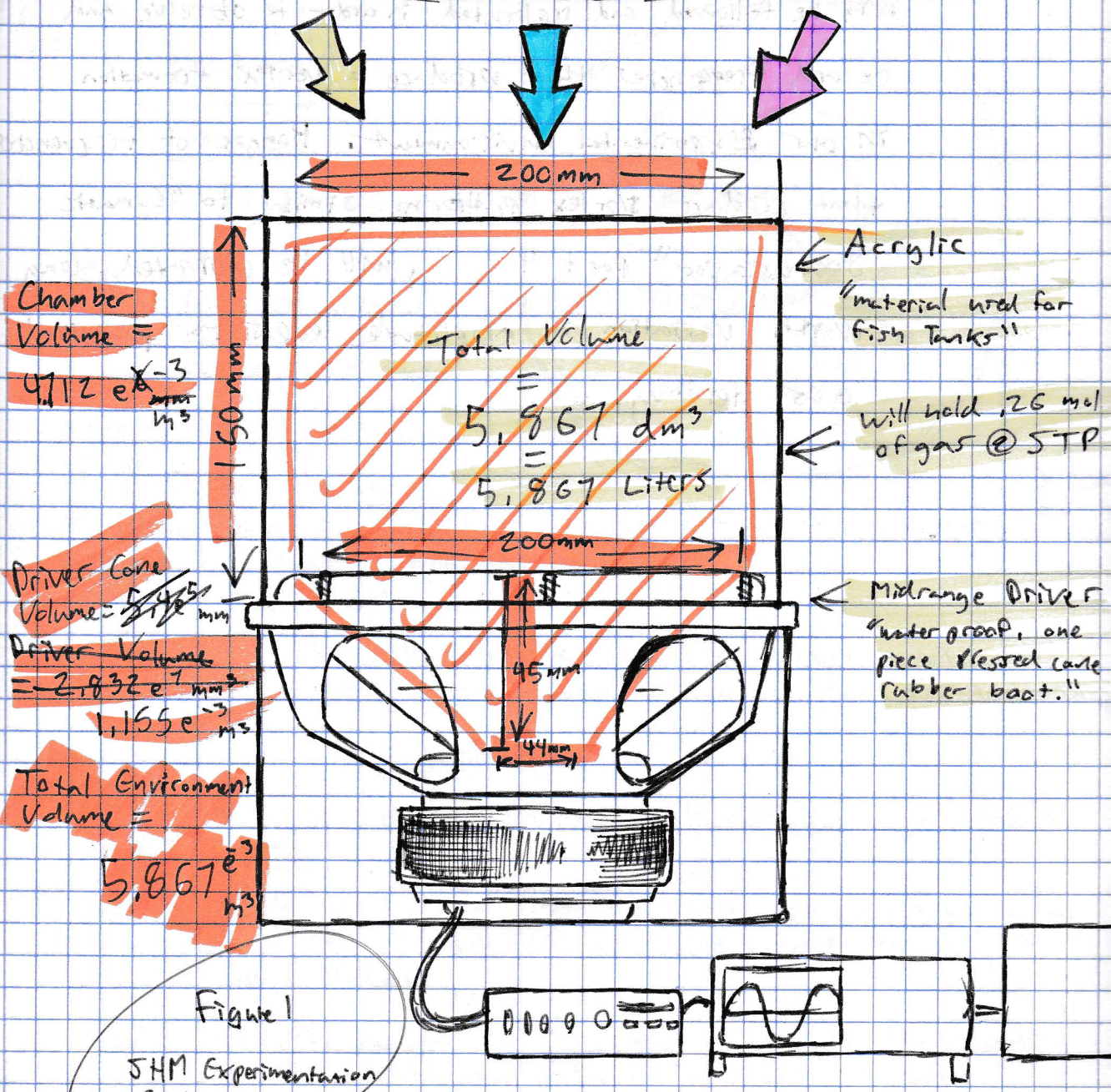
+ Lycopodium Oscillation with Paper diaphram
+ Laser Path tracking and Period Calibration + Calculation
+ Partial Pressure and Total Pressure testing of THM of gas
+ Plasma Ionization and experimentation

Lab Environment

flat cap w/ high range output

diaphram cap w/ paper Diaphram or/ rubber Diaphram + mirror

flat cap



Chamber Volume =

4.712 e^{-3} m^3

Driver Cone Volume: ~~5.145 e⁻⁵ mm³~~

~~Driver Volume = 2.832 e⁷ mm³~~

1.155 e^{-3} m^3

Total Environment Volume =

5.867 e^{-3} m^3

Figure 1

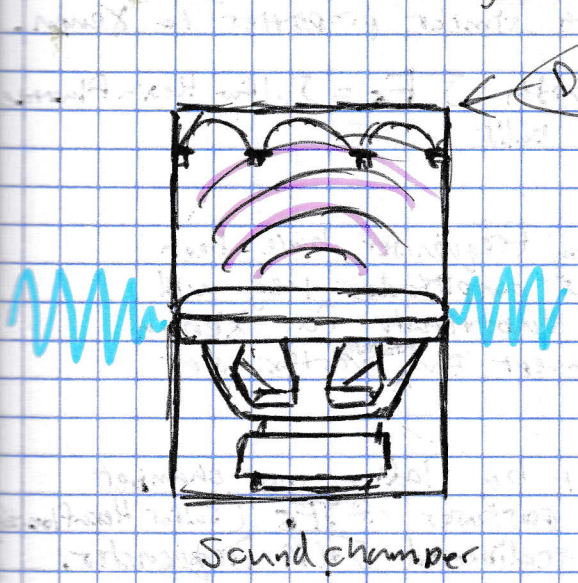
SHM Experimentation Environment.

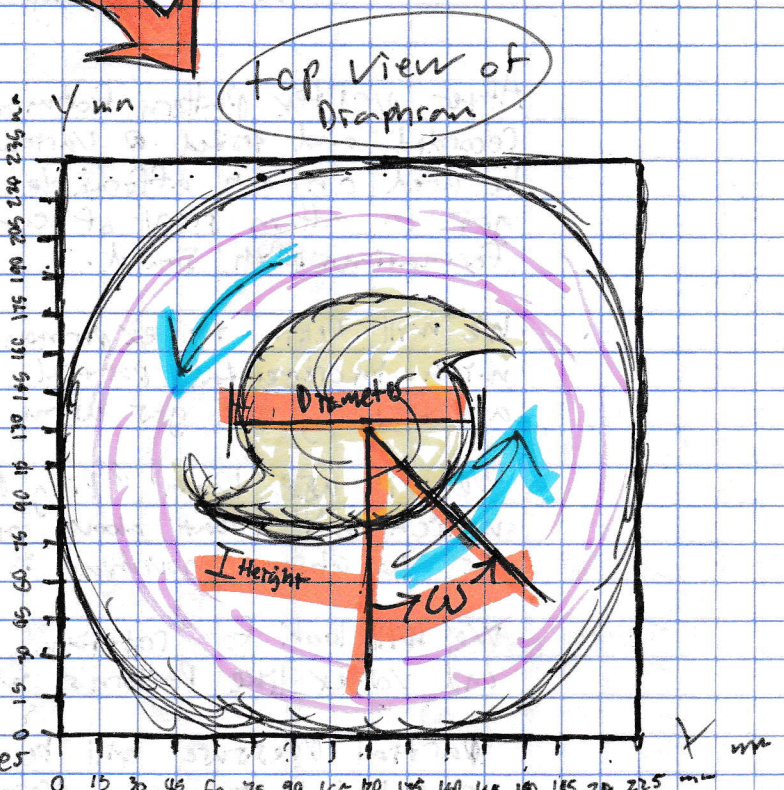
3A

Part II calibration of frequencies that create a vortex formation.

In this portion of ~~this~~ our experiement, experimentation on sound and the form of matter done by Hans Jenny will be followed and replicated in order to observe and record freqencies that produce a vortex formation in our Experimental environment. Ranges of frequenc that produce vortex patterns similar to "Cymatic Soundscapes" part 4 , will be calibrated along with variation in amplitude levels for pressurized gas testing.

Lycopodium Calibration





Step 1: add thin layer of lycopodium powder to paper diaphram on sound environment

Step 2: Begin testing full range of frequencies adding additional Lycopodium powder to increase visualization and maintain layer.

Step 3: find Vortex Patterns and experiment with adjustment of frequency and amplitude for formation stability

Step 4 measure width, depth and angular velocity of vortex

Step 5 scale vortex to size for inside of container using gas. Use Amplitude, Volume of medium and frequency adjustments

Step 6 write down frequency and amplitude combinations and volumes of lycopodium used to create vortex.

Part III Testing Calibrated Vortex Frequencies using Inert gas with similar properties to Xenon

SHM Testing with SF_6 = Sulfur Hexa fluor and "Ping Pong" balls

After Vortex Pattern forming frequencies have been recorded and tested @ various amplitudes they will be used on an affordable substitute for Xenon gas to attain proof of concept for ~~a~~ atomic Vortex gas formations with Sound.

We will begin the experiment by loading our chamber with incremental partial pressures of SF_6 (Sulfur Hexaf and testing our gas using calibrated SHM frequencies.

We will use 10 mm "Ping Pong" balls in our chamber, which will float above our layer of SF_6 and allow us to observe movement in our gas layer.

We will look for rotational movement of the "Ping Pong" and vortex like patterns which we observed in Lycopod

Partial Pressure will be increased for SF_6, whi Our total system pressure will not increase abov

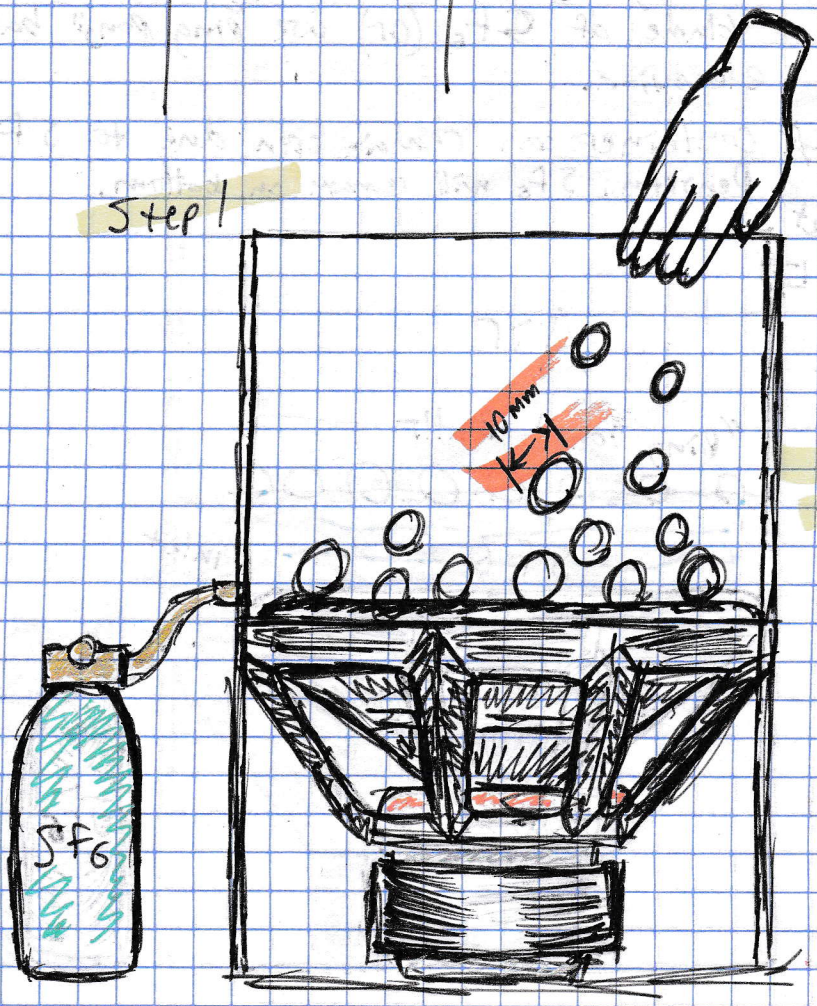
Depending on the limitations of our constructed pressu SHM chamber, we will attempt to use a total system pressure as low as .1 atm

We will increment concentration of SF_6 as follow

Run	SF_6 %	Other Gas (Air) %
1	10	90
2	15	85
3	20	80
4	~~20~~ 25	75
5	30	70
6	35	65
7	40	60
8	45	55
9	50	50

	SF_6 %	Air %
10	55	95
	60	90
	65	35
	70	30
	75	25
	80	20
	85	15
	90	10
	95	5
	100	0

Step 1



Add "Ping Pong" Balls

Measure "Ping Pong" Ball mass with Uncertainty

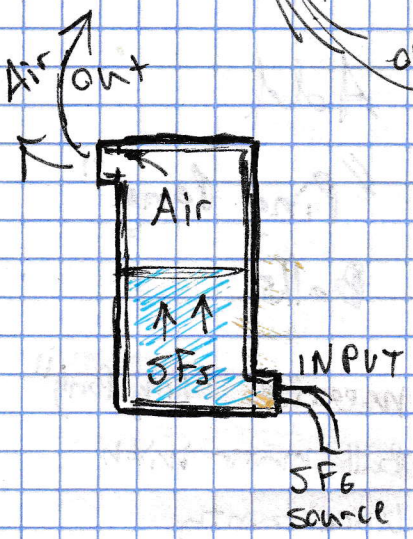
- ★ 10mm Ping Pong Balls will be used to visualize gas movement patterns.
- ★ Balls will float on Dense layer of SF_6
- ★ Balls will move with vortex pattern.
- ★ Video recording can be used with sphere tracking software for future analysis.

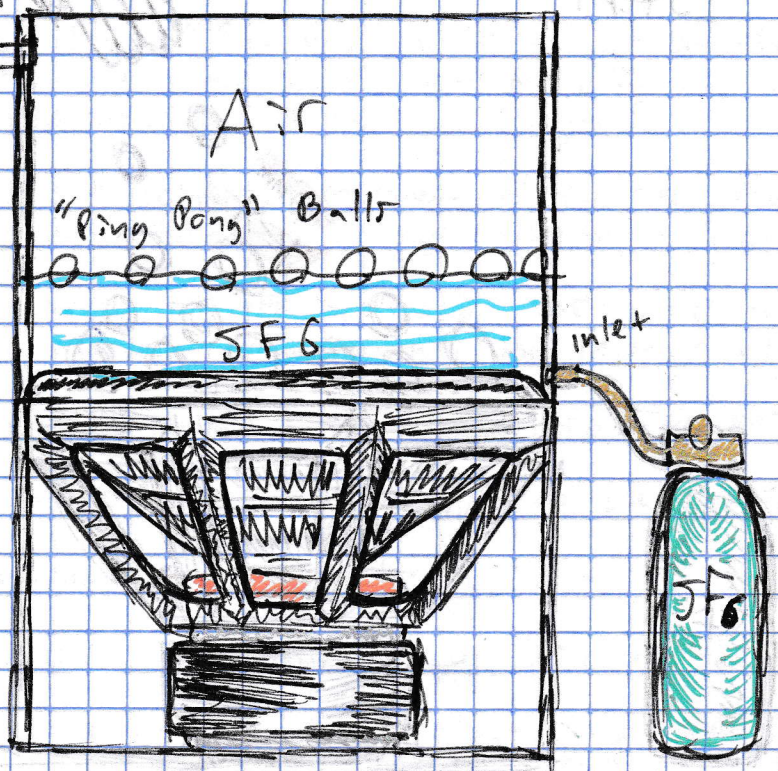
SA

Step 2 Add SF_6

Dense gas will Displace Air

- ★ fill from bottom, density of gas will displace air out of top
- ★ use gas flow meter to calculate volume of SF_6 (or) use "ping pong" ball elevation.
- ★ container can remain open due to SF_6 Density. SF_6 will remain on bottom.





measure: Diameter of measurable vortex
Angular velocity ω
Angular acceleration α

- ★ use mass of Balls to determine force of vortex from angular acceleration
- ★ find Concentration of SF_6 which offers best Acceleration of "Ping Pong" Balls.

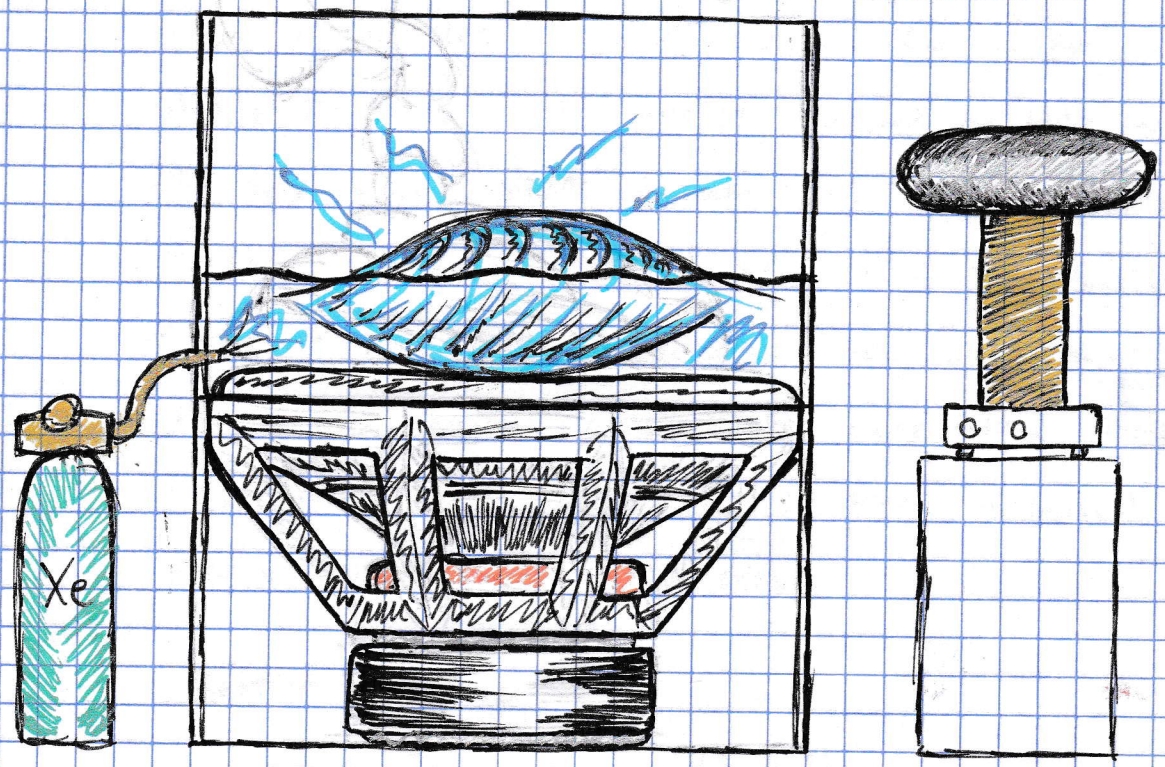
Methods - Part IV

Step 4 Add Xenon ~~Sound~~ / Create Vortex

★ Using Measurements and Data collected in Step 2 for harmonic activity in gas, we apply tuned Frequencies to Xenon gas at the concentration which allows for the best vortex pattern on SF_6

★ ~~We~~ After formation of vortex patterns, an electrode will be introduced in oder to create a plasma within the vortex.

Measure ~~Increase in temperature~~
- Diameter of Vortex formation
- Visible Angular Velocity ω
- Visible height
- temp w/o sound
- temp w/ sound + After Plasma
- pressure w/o sound
- pressure w/ sound + After Plasma



~~Compare E with~~

★ Calculate Energy change of gas plasma with and without sound

★ Compare with the Energy Output of speaker and electrode, Equipment will vary so comparison is not necessary

1/24/18
6A 10:02 ch

Part III B Testing Calibrated Frequencies With CO_2 Vapor "Dry Ice Gas"

Step 1 Initiate Calibrated Frequencies

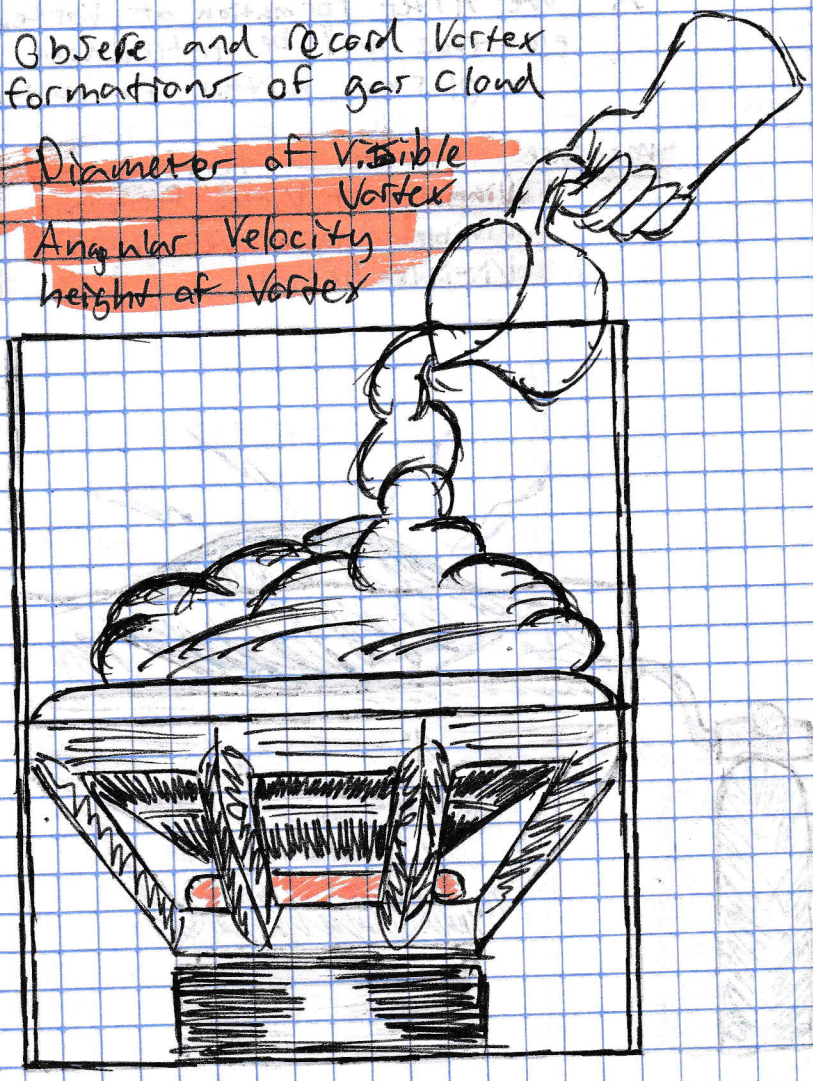
Step 2 Add incremental levels of CO_2 gas Vapor from Sublimating Dry Ice.

Step 3 Observe and record Vortex formations of gas cloud

~~Record~~ Diameter of Visible Vortex

Measure Angular Velocity

~~height of Vortex~~



Look into temperature Tollerance of Speaker VS CO_2 gas to ensure enclosure is not damaged

Equipment, Reagents, Supplies and other Needs:

Equipment needed for this experiment includes materials needed for constructing the sound chamber, and Reagent Mediums which will beased for testing.

Other supplies requested for this experiment include published materials by Hans Jenny which demonstrate many of the procedures which will be replicated In the early stages of calebration of freequencies and amplitudes used for vortex formation.

Aside from materials directly related to this type of experiment, Video documentation and measurement hardware will be critical for measuring physical Qualities, in cases where we may only have short time periods available for observation. Video Recordings can allow us to make detailed measurements and calculations.

Reference Materials

Cymatic Soundscapes DVD - Hans Jenny

Cymatics: A study of Wave Phenomena (2001)

7A

Recording and measurement hardware

DSLR Camera

Pro Taper - measurement tape — Can use Regular tape

Infrared thermometer

Laser switch — Available on Campus

Visible laser diode mirror - can use mirror

Slow motion Camera - Rent?

Wireless pressure sensor

Digital Sound Level meter.

Materials for gas/plasma SHM Testing

wave driver, monitor and Power Supply

Reagent Grade Lycopodium Powder

Sulfur Hexafluride SF_6

CO_2 gas / Dry Ice

6" midrange speaker, water proof, propelene, rub

Acrylic Chamber Cylinder 6" OD diameter

Acrylic sleeve cylinder $\phi 7\frac{3}{4}$" ID diameter

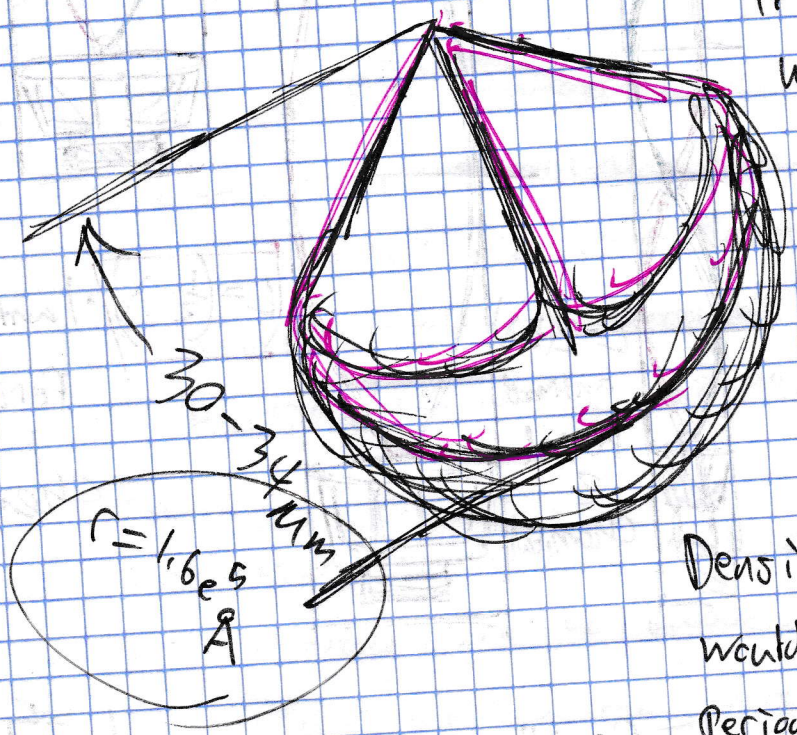
Acrylic sheets

Valves, Piping and gas components

Screws and Fasteners + Components

Possible Issue

Density of lycopodium
= 1.06 - 1.09 g/cm³
Radius of Lycopodium
= 1.6 e⁵ Å



Trigonial Pyra
with Curved

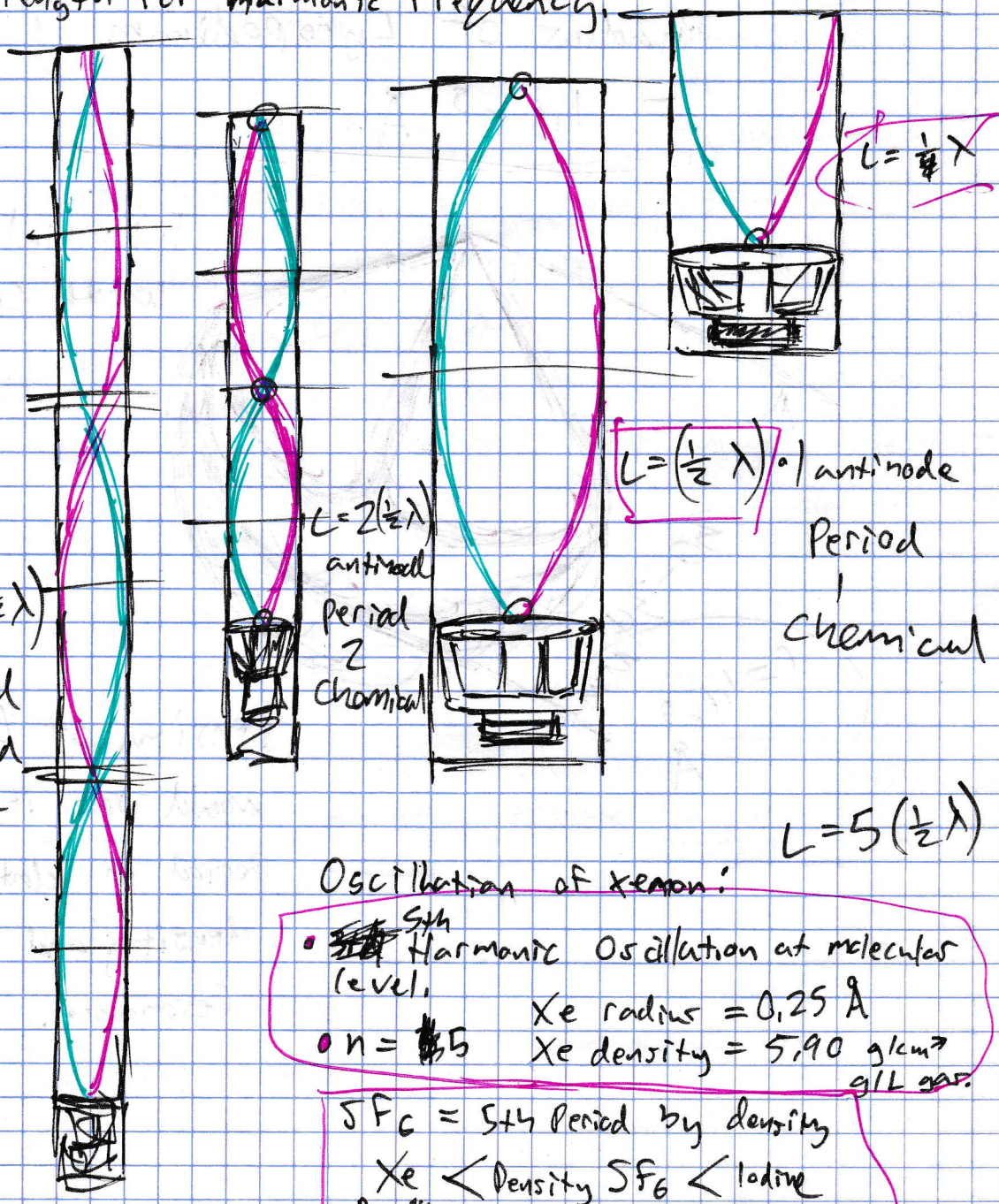
Density of Lycop
would out it in
Period in relation
density and mas
resonance.

Thurs Jan 30th 13:24

Chambes size

Current Issues

- different frequencies resonate @ Δ wavelengths
  chamber for oscillation should match optimal length for harmonic frequency.



Oscillation of xenon:

- ~~5th~~ 5th Harmonic Oscillation at molecular level.
- $n = 5$

Xe radius = 0.25 Å
Xe density = 5.90 g/cm³
g/L gas.

SF_6 = 5th Period by density

Xe Density < Density SF_6 < Iodine Density