Column Scents
Cheyenne East High School
HUNCH Project
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Introduction

For our project, we tested the rate of diffusion of a gas in micro-gravity against the rate of diffusion in regular gravity. For a gas we used a Volatile Organic Compound (VOC), specifically 100% essential cedar wood oil. The over all goal is to potentially make the life for astronauts on the international space station better by the use of scents.

Abstract

We developed a systematic procedure to release fragrant organic essential oils under microgravity conditions. By the use of specialized sensors for volatile organic compounds (VOCs), we measured sensor readings for specified areas of diffusion of the volatile organic compound. The knowledge used from this experiment will be applied to an experiment, proposed to improve the scents on board the ISS for astronauts.

The experiment consists of a clear Lexan container. It is divided in two by the slide, which divides the scent area from the area with the sensors. Within the container, in the scent area, is approximately a 2 cubic centimeter square sponge soaked in a 100% essential oil. Three sensor boards with Figaro volatile organic sensors are attached at various distances from the sponge containing the essential oil. The Lexan container will be placed in three different positions which are vertical, diagonal, and horizontal to observe if any difference in readings are due to the position of the Lexan container. The data will be collected by a Labquest connected to the sensor board, during microgravity conditions. This data is compared to data collected after the plane had landed at Ellington Field, as well as some hyper gravity runs conducted on the second day of flight.

The results indicate that there was a difference between the three different strengths of gravity. At least for the vertical position, the hyper gravity took longer than the regular gravity, which took longer than the microgravity. We took the ground data the same day as the second flight to help control the aspects of temperature, pressure, and humidity.

Research Problem

The experiment was flown as part of the High School Students United with NASA to Create Hardware (HUNCH) program. It was designed, fabricated, and documented by the students at East High School in Cheyenne, Wyoming. The reason for doing the project is to determine the differences of rates of diffusion of a volatile organic compound in microgravity conditions compared to 1G. The experiment tested the rate of diffusion of a volatile organic compound and the direction of diffusion under microgravity conditions. We recorded the measured voltage from Figaro volatile organic compound sensors that are placed within a Lexan box and are exposed at various distances and directions to a volatile organic compound. The rationale for this experiment is to determine the nature of diffusion of volatile organic compounds in microgravity in order to understand how scents will disperse on the ISS.

Our research began with the idea that there is a lack of pleasant olfactory stimulation on the ISS, so we explored ideas as to how we could better the smell. Initially, we tried to use reeds and oil bottles to disperse the smell. We planned to use several small bottles containing different scents to stimulate the olfactory sense differently during different times of the day, for example coffee in the morning. The idea was to increase the astronauts productivity, as well as their comfort if we use different smells for different situations. To determine the optimum positioning and quantity of scent to use was our first step and the reason behind our zero gravity flight.

After the experiment, we took a tour of the food lab at NASA, and they pointed out that the sense of smell is dulled to the astronauts and that the food sometimes tasted different, not just because of the lack of water, or the food being freeze dried, but because smell is a part of taste. A side idea was to possibly attach some scent producing item near the food to increase the astronaut's taste to "normal".

Method:

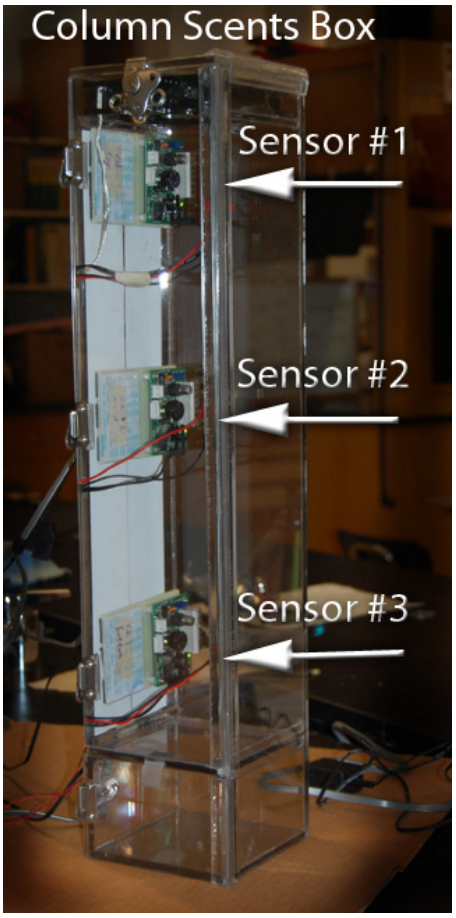
How did your research begin?

The research began with the question of how do we detect scents on earth and in microgravity conditions scientifically. We researched the E-Nose that was on the ISS and contacted the Principal Investigator Dr. Amy Ryan. She was willing to help with our experiment. She told us about the Figaro sensors that can detect volatile organic compounds. Kazuaki Wantanabe at Figaro Inc. helped us select two sensors that might work and we tried them both. After testing both sensors we decided on the TGS 2620 sensor and its board.

As time went on, we discovered that the question needed to be narrowed. So we decided to focus on diffusion of the gas, because how much of the smell is needed as well as how fast it diffuses throughout the ISS. The other part of this experiment was based off of how other phases act in space. Liquids act different in space, then won't the gasses?

Describe your experiment setup.

The experiment is contained inside a box constructed from Lexan, which will be placed inside a NASA Reduced Gravity Office Glove Box to provide the double containment and eliminate the need for a stress analysis. The experiment relies on Figaro volatile organic sensors attached to a sensor board that reads changes in voltage across the sensors when volatile organic compounds are sensed. A base for the Lexan box that contains the sensors is constructed so that the box can be positioned horizontally, vertically and at a 45 degree angle. There will be a fan at the top of the box to eliminate the scent after each parabola or two. Pellets of charcoal will be used to help absorb the VOC from the glove box, and was taped down in a corner. A Vernier LabQuest will be connected to the sensors and velcroed inside the glove box to record data from each sensor in the box. The VOC will be contained in a sponge, contained in a sealed cavity away from the sensors at the bottom of the box.



(c) **What were your hypotheses?**

The hypothesis was that the VOC would have a different diffusion rate because the
rate of diffusion might increase without gravity, all because an extra force is removed however minor it is. The equation for diffusion has never needed a gravity factor because we have not needed it for space to this precise degree.

(d) What research did you do prior to your flight?

Our research began with a previous experiment that had flown on Space Shuttle Discovery Flight STS-95. The company International Flavors & Fragrances flew an experiment with a rose to see how its essential oil production changed in zero-g, as essential oils are what give flavor and fragrance. In the end we found a new compound of rose oil that was new and hadn't been seen anywhere else before. [1]

(e) What tests did you do to prepare?

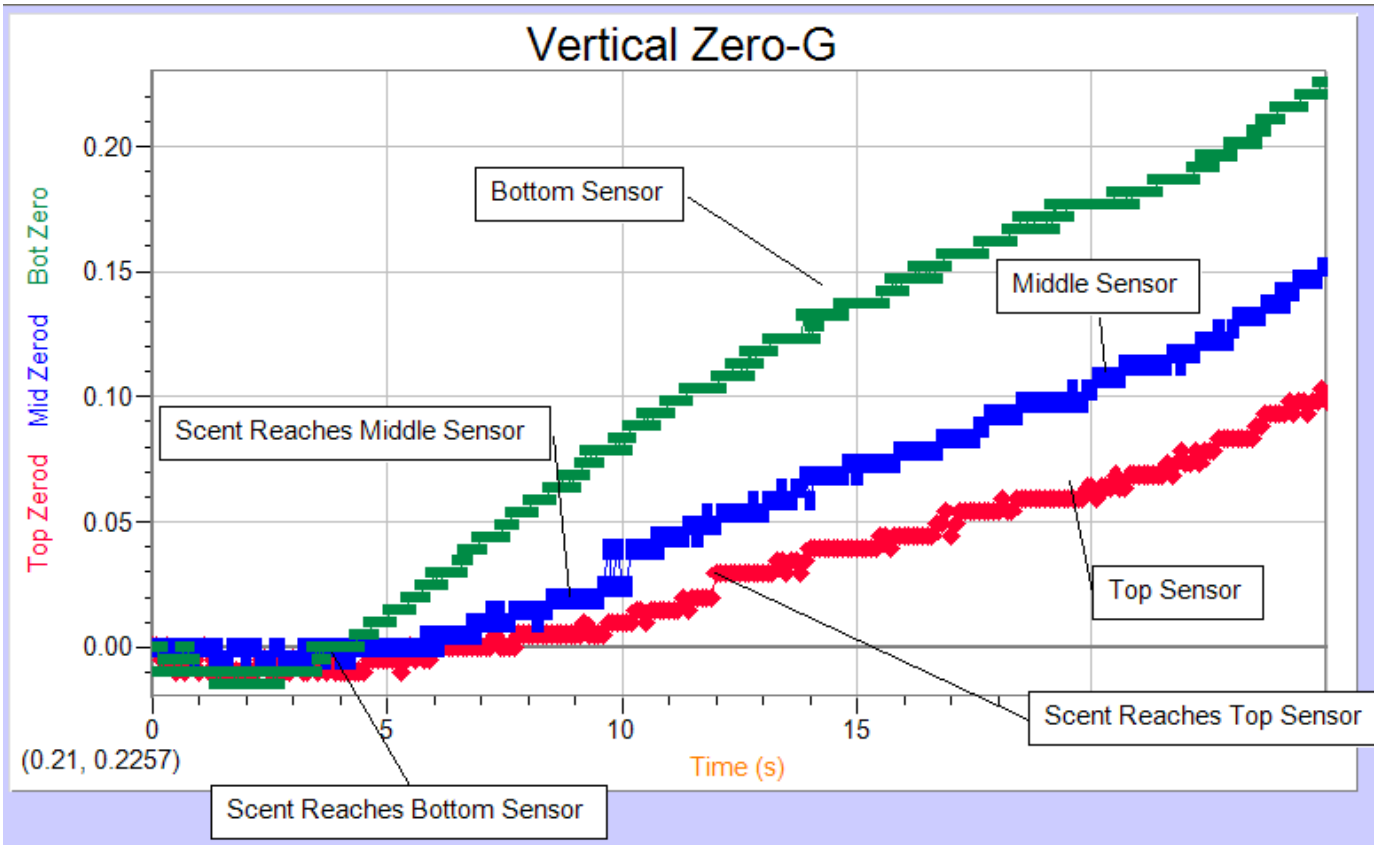
We ran tests to determine several things. First we tested whether or not from viewing the sensor's change in voltage if we could tell when the scent reached the sensor, and we were able to. Next we built a wooden box similar to our final Lexan one to test the distances from the scent source as to what could be sensed in the time of the micro-gravity parabolas. Finally, we tested our final experiment setup; how effective our fan would be at venting the smell, how well our Labquest would be at recording the voltage from all three sensors at the same time.

[1]http://www.nasa.gov/audience/forstudents/9-12/features/spacescents_feature_prt.htm

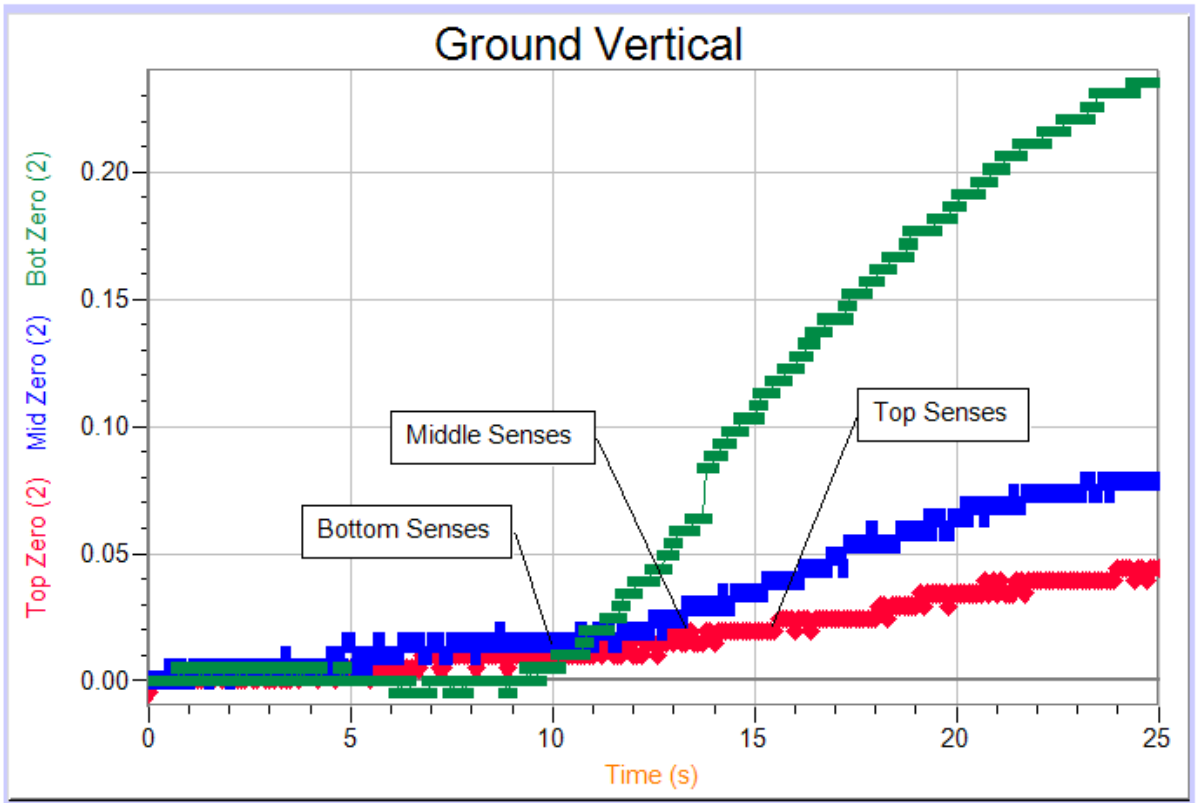
Results

The results from this experiment was that there was a difference between Earth gravity, micro-gravity , and hyper gravity, with the vertical position at any rate. The rate of diffusion was higher in zero gravity than normal one g gravity and the rate was slower in hyper gravity than normal gravity.

This is how we analyzed all of the data. First we subtracted the initial voltage measured from the rest of the measured voltages to “zero” the data. We then determined the time when the sensors “saw” the scent based on when there was a great increase in the voltage measurement. In the case of this graph, the bottom sensor, the one closest to the sponge represented by a green line sensed it at about 3.4 seconds. The next sensor (blue line) saw it at 8.5 seconds, and the top sensor saw it at 12 seconds.

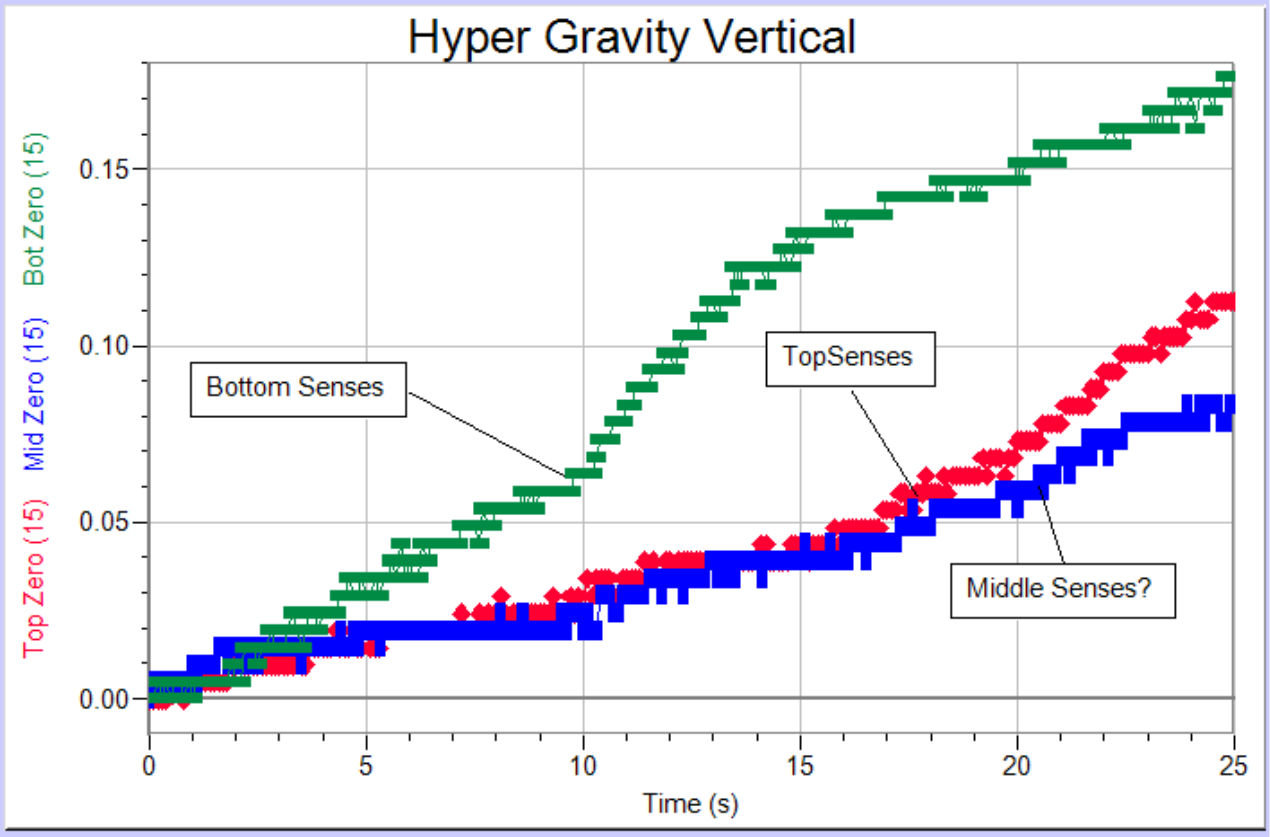


We then compared it to Earth gravity data of the same position.

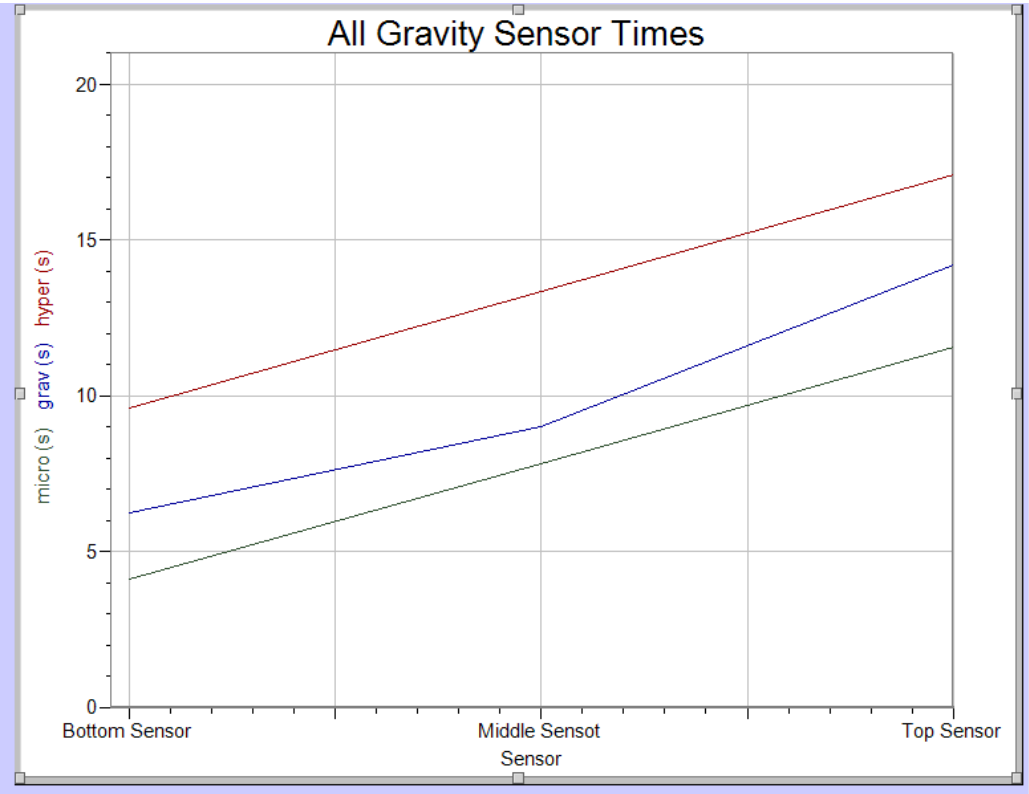


In this case the bottom sensor saw it at about 10 seconds, the middle saw it at 12.8 seconds and the top at 15.5 seconds. This means that the scent took 6.6 seconds longer to get to the bottom sensors, 4.3 seconds longer to get to the middle sensor, and 3.3 seconds longer to get to the last sensor.

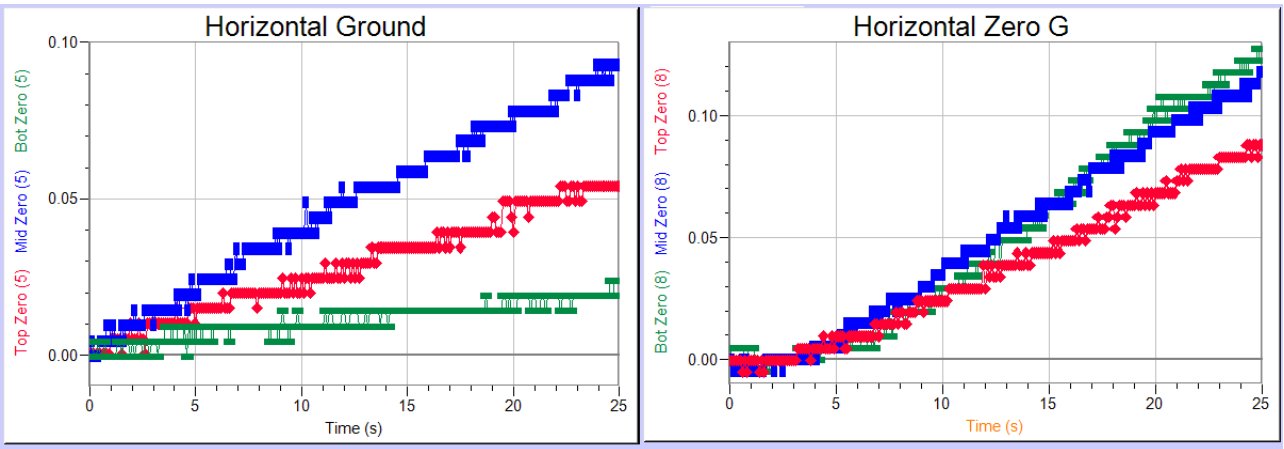
Next we compared these two to hyper gravity.



The first thing noticeable in this graph is that the top sensors sees the scent before the middle one does, and ends at a higher voltage than the middle. This may be from over saturation of the sensor through out the course of the flight, as this data was taken towards the end of the flight after several runs. If we ignore the middle sensor and take the times for the bottom and top sensors with times of 9.8 and 17.1 respectively, and combine them with the other two, and make a graph of the sensors with the times it took to reach them for the three different gravities we get a graph like this:



This graphs shows the times it took for the scent to reach the sensors under the three different gravity fields, the top red line for hyper gravity, the middle blue line for Earth gravity, and the bottom green line for micro-gravity. As shown in the graph, it took longer the higher gravity strength. However this is only for the vertical position, for the other ones, we are not quite sure what it all means, for example the horizontal:



In the ground one, the sensors sense in an order not expected, middle goes the highest, then top, then bottom. The zero-g one is in the expected order, but there is really no drastic changes like we saw before, as the range of both graphs is from about 0 to 0.1 volts, about half of the others. It seems that it hit the sensors all gradually, increasing all

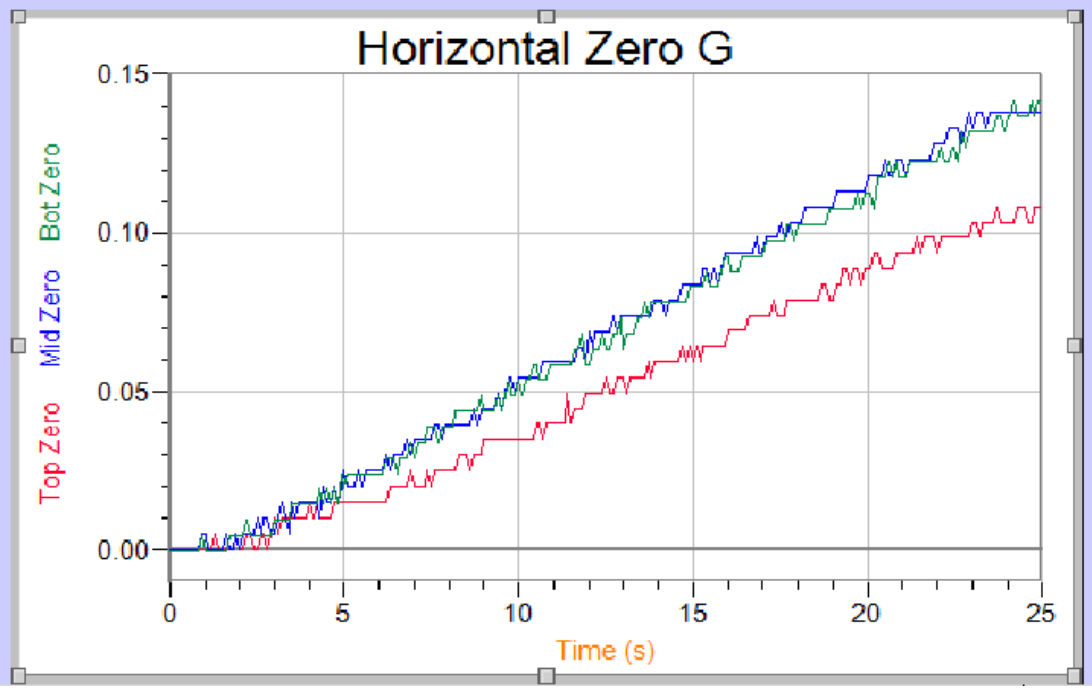
of them, how ever, as to why this happened we aren't very sure.

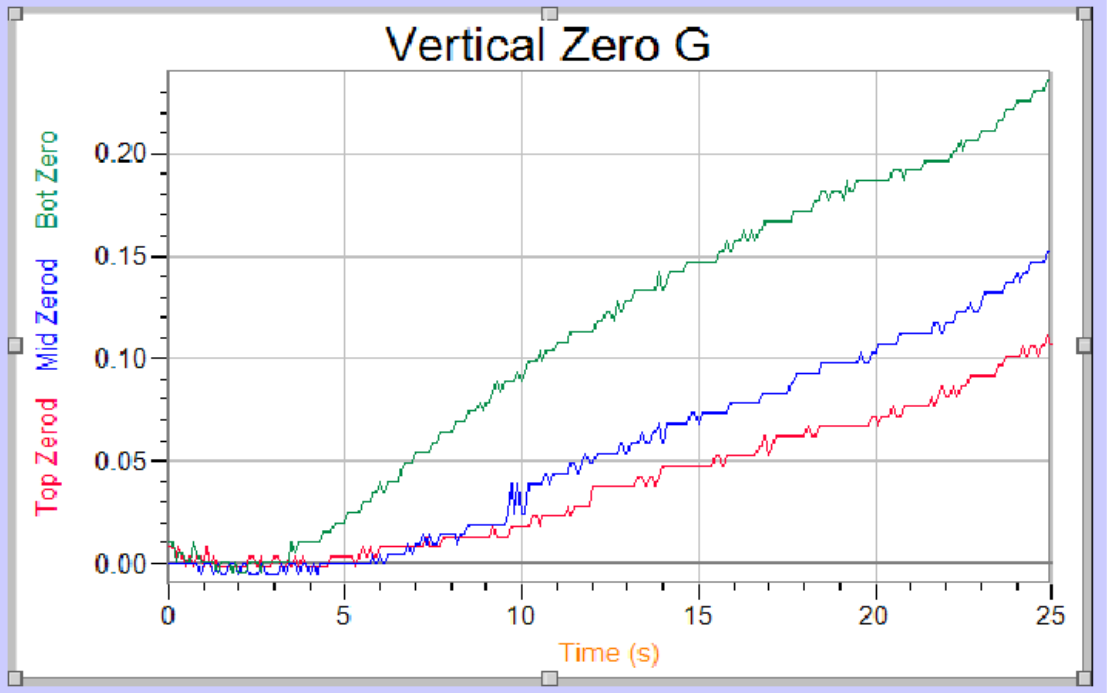
Discussion

In our hypothesis, the vertical position in gravity will diffuse slower than the vertical position in zero gravity. This is due to gravity's effect on the molecules. The molecules have mass, and therefore will have a slower diffusion rate in gravity. This hypothesis was verified by the results.

In our hypothesis, the horizontal position in gravity will diffuse the same as the horizontal position in zero gravity. This is because we think the gravity wouldn't affect how fast the gas would diffuse perpendicular to the gravity field. This is what we found, they both acted in a similar matter, on ground and in zero g.

Our problem with our results was in comparing micro gravity horizontal and vertical micro gravity. We expected the results to be the same, however, the vertical position acted more like we expected while the horizontal acted unexpectedly.





Based on these graphs, and others, the vertical and horizontal positions did not work in the same manner in zero g., and we aren't completely sure why. We expected them to be the same, but with the horizontal, on most of the graphs, all the sensors seemed to detect the VOC at the same time, while that only happens once with the vertical position. For most of the vertical position runs, the bottom sensed the VOC first, then the middle, then the top. This was not true for the horizontal position. From this we must conclude that there is something else affecting the gas, but we aren't sure what.

Conclusion

(a) What did you learn?

Gasses diffuse slower in hyper gravity than gravity, and gasses in gravity diffuse slower than microgravity in the vertical position.

(b) Now that you have tested your experiment..... What would you change if you were to re-test the experiment again?

One major change would be to add an activated charcoal filter at the end of the column by the fan. This would force the air to go through it and possibly rid the scents better. We noticed both days when we opened the glove box that there was a strong smell of cedar wood oil lingering in the box. The other thing would be to check if charcoal is effective at absorbing the VOCs. Also, we could have added another door

near the bottom of the sensor containing column, so that you don't need to remove the smell in order to vent. Adding two different sensors of different sensitivity to measure concentration more accurately would also be a good idea. Then there is the idea that the different VOCs may diffuse at different rates. Lavender oil may diffuse and have different properties than the cedar wood oil. The last idea we came up with to make the experiment better would be to engineer a better way to start the experiment. The uncertainty at the start gave 1-2 seconds of uncertainty from the actual “start”.

(c) How would the research you conducted contribute to NASA’s goal of heading back to the moon, on to Mars and beyond?

We want to try and make the astronauts' lives on the International Space Station better through the use of scents. We want to disperse the least amount of a smell into the ISS as possible to make the scent detectable, to create a more productive environment and help preserve the sense of smell. The thought is that an awareness of the 5 sensory organs can make the experience on the space station safer and more enjoyable for the astronauts. Also, the idea of making food more enjoyable may be implemented.