Applying MEMS Pressure and Temperature Piezoelectric Receptors to Determine Specific Ideal Gas Law and Molar Quantities through Chemical Analysis and Mathematical Modeling.

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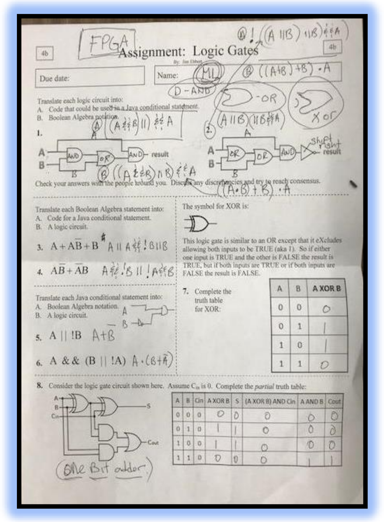
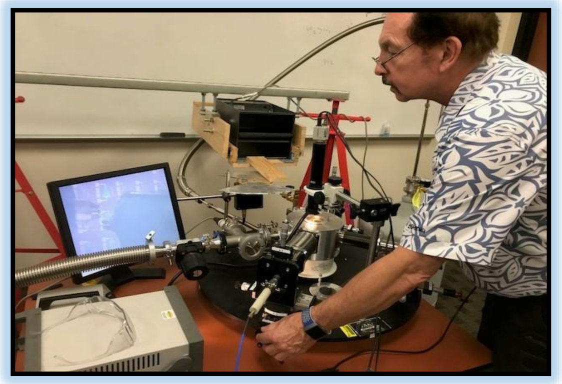
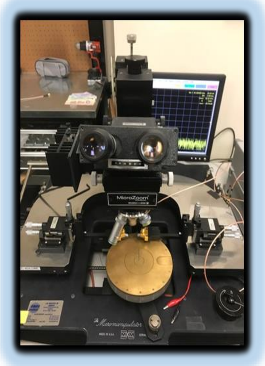
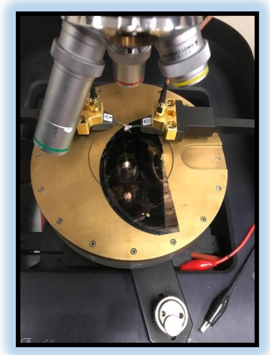
NSF/RET/CoMET

Summary





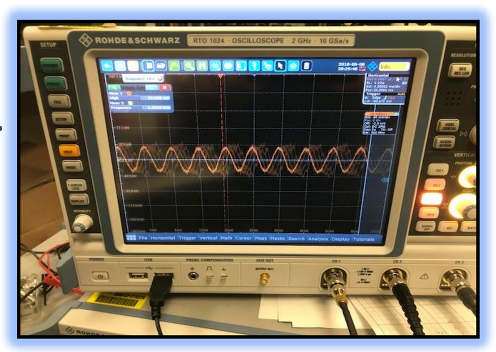




During the RET program additional time was allowed to build and enhance my knowledge of each topic prior to our lecture and discussion. This process is similar to an OCPS initiative to move towards a flipped classroom. Having experience with this process reinforces the value of OCPS's goal of moving towards the flipped classroom. With proper planning and allowing students directed personal research the flipped classroom could be very successful. Dr. *Abdolvand* is always challenging us in the lab, and although tough, this technique is important to being successful in many applications. I plan on providing similar challenges to my high school students during their lab activities and having students answering how, what and why questions, focusing on the why questions.

Research Activities

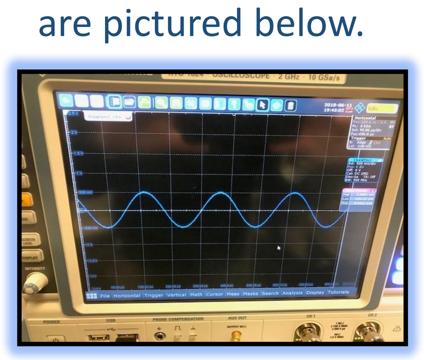
During the lab activities we were able to use a piezo-electric device and measure the accuracy of a tuning fork. We glued the piezoelectric device to the tuning fork then connected it to an oscilloscope. Data and device apparatus are shown to right….

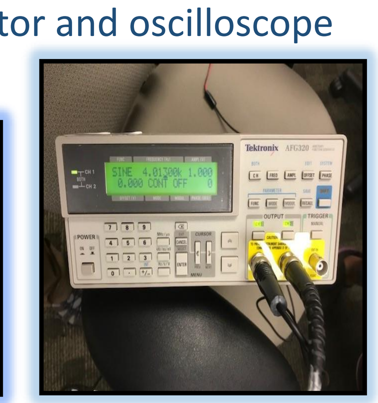


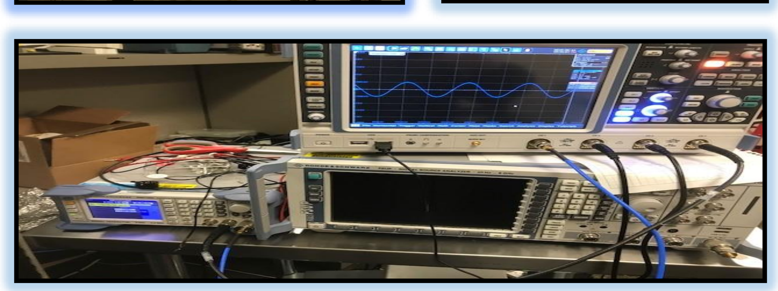
Frequency (Hz)	Peak Output
	Voltage (mV)
2000	0
3000	150
3900	275
4000	400
4013	400
4100	475 noisy
5000	250
6000	150
7000	140
8000	200
9000	0
10000	20
12000	5

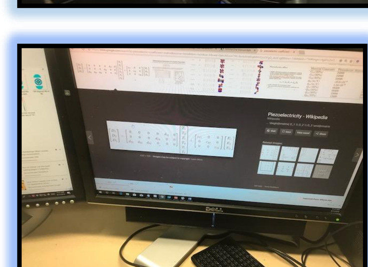
Lab Data Results: Study question: Determine the frequency of a sensor (buzzer) and make the device oscillate. We hypothesized that this could be achieved by applying different frequencies to determine the actual voltage. ***Data is shown above.***

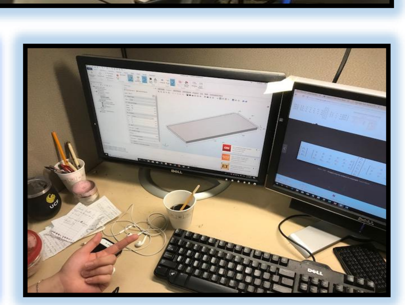
…..from these results, we were able to determine that the resonance frequency highest peak was 4100 Hz. We determined that the highest peak represented the actual resonance frequency of the device and also had the highest voltage output (mV). Data from the frequency generator and oscilloscope are pictured below.











Above Right demonstrates the movement patterns of a resonator, which was manipulated for both 2nd to 3rd order. **Above Left** is a sample design for a piezoelectric device.

Lesson Plan

Learning Objectives

Generation of a Hypothesis Using the Scientific Method: SC.912. N.1.1 Define a problem based on previously researched knowledge, of Stoichiometry and Gas Laws, and complete the following tasks:

- Pose questions about your research
- Examine books resources of information to see what is already known about your topic.
- Review the lab procedures and have a specific plan to conduct your experiment.
- Generate your hypothesis based on your research. Your hypothesis may be in the form of an if/than statement.
- Conduct organized observations during your experiment and record your data.
- Pose answers, explanations, or descriptions of your experiment.
- Use appropriate evidence and reasoning to justify these explanations to others
- Communicate results of scientific investigations through your lab report.
- Evaluate the merits of the explanations produced by others.

Stoichiometry: SC.912. P.8.9 Apply the mole concept and the law of conservation of mass to calculate quantities of chemicals participating in reactions.

Gas Laws: SC.912. P.12.10 Interpret the behavior of ideal gases in terms of kinetic molecular theory.

Lesson Plan Agenda

Day 1: Students will take a pretest, then research specific topics (via a research activity) related to the learning objectives *(learning objective 1).*

Day 2: Students will continue their research and use this research to begin the first steps of the scientific method *(learning objective 1).*

Days 3 and 4: Lecture/Class Discussion *(learning objectives 2 and 3).*

Days 5 and 6: Solving Stoichiometry and Gas Laws Problems *(learning objectives 2 and 3).*

Day 7: Begin the lab activity and collect data *(learning objectives 2 and 3).*

Day 8: Continue the lab activity. Use appropriate evidence and reasoning to justify data explanations to other lab groups *(learning objectives 2 and 3).*

Day 9: Begin writing rough draft of lab report and complete any lab activities *(learning objectives 1, 2 and 3).*

Day 10: Write lab report and submit the rough draft *(learning objectives 1, 2 and 3).*

Day 11: Evaluate the merits of the explanations produced by others, one-page report with specific examples and justifications *(learning objective 1).*

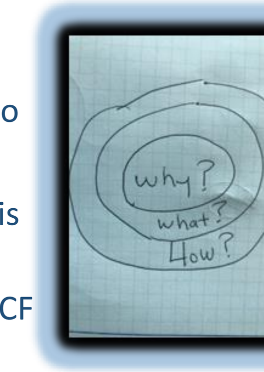
Day 12: Class Discussion and Post Test *(learning objectives 1, 2 and 3).*

Lab Activity

In the lab activity, students will use **"PV = nRT"**and:

1. Produce their own CO_2 gas and measure with prodigious accuracy w/o making any assumptions or guessing.
2. Generate a hypothesis that tests the stoichiometric ratios of an experimental vs theoretical yield.
3. Scaffold previous knowledge of moles and apply present knowledge to your results.
4. Enhance your prior knowledge of lab techniques and lab apparatus to apply gas laws for use in practical applications.
5. Preform a precise chemical reaction to produce CO_2.
6. Measure the pressure of CO_2 gas using a piezoelectric device ***pictured above*** then determine, via calculation, the moles of gas.
7. Measure temperature of a CO_2 filled balloon with a piezoelectric device to determine the moles of gas.
8. Create a mathematical model related to your experiment to predict accuracy and precision of future experiments.
9. Calculate your experimental percent error.
10. Relate your findings from the experiment to a real-world situation and be challenged to design your own experiment and make mathematical models to demonstrate your design.

Lesson Learned and Assumptions



✓ ***Working** in Dr. Abdolvand's lab* has been an enlightening experience. Pertinent to his lectures, the major "take away' s" curtail from his viewpoint is that **problem solving** is the key to all research, and the **process** of getting to a solution is the mechanism to getting results. This philosophy carries over in my classroom during lab activities. It's clear that research topics and techniques taking place at UCF laboratories produce sensational products that can be shaped by this process. The PowerPoint tutorial presentation I produced at the end of the **RET** program for my Chemistry classroom and colleagues, highlight the important research projects taking place at UCF Engineering labs. Exhilarating research, such as that taking place at UCF laboratories inspire dialog towards motivating students into STEM careers.

✓ Asking students **challenging questions** is vital to making them think about what, how and why. I plan in implementing this practice into my classroom. The essence of this teaching technique is provided in a simplified diagram above.

✓ *Dr.* Abdolvand also generated a conversations about **best practices** in learning complex topics, and that memorization is not as important and how a student can actually perform or solve a problem. For example, formulas and equations can easily be found and don't really need to be memorized, it's the process a student goes through to find a solution that is most important

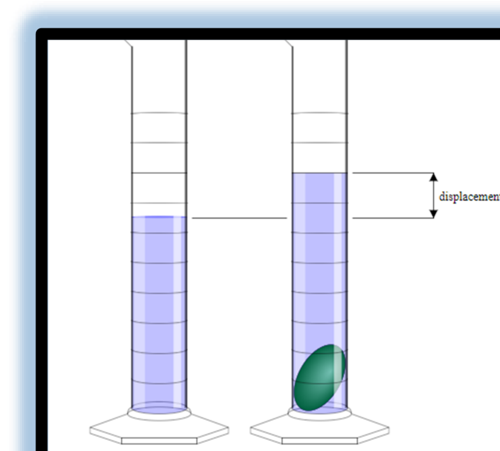
✓ Much effort went into **C and JAVA** programing. This information is invaluable so that I can properly council students on how to find and use these resources. In addition, this research insight will be vital to promote interest students into STEM, Science, Programing and Math careers.

✓ I can incorporate programming games in my classroom such as https://www.chemdoodle.com/ where students may use the features below:

- **Drawing and Graphics** – Using new systems for producing graphics in the chemistry classroom.
- **Chemistry** – Using State-of-the-art implementation and advanced programs including the analysis of advanced aromatic resonance structures. Full support for the latest elements as defined by **IUPAC**!

Implementation Strategy

This lesson plan will be applied to Honors Chemistry classes at WPHS and shared with colleagues . This curriculum will be covered following Stoichiometry, as a lead into Gas Laws, during the beginning of the 4th 9 weeks, typically after Spring Break. The knowledge gained by the students is critical to understand quantitative chemistry.



Students will gain experience **working in groups** during an **inquiry based learning** lab experience, while researching the topic, writing a lab report, sharing information and data with other lab groups, and while writing and providing input from their lab reports. During the lab, students will be **using technology** to complete their assignment. Students will be **scaffolding** previous knowledge from stoichiometry and apply this knowledge towards Gas Laws. The lesson includes sufficient **differenced instruction** within each component.

Acknowledgments

RET Site: COMET Program, College of Engineering and Computer Science, University of Central Florida. This content was developed under National Science Foundation grant EEC-1611019. I would like to personally thank Dr. Cho, Dr. Abdolvand, Dr. Turgut, Mr. Jim Ebbert, all of the outstanding guest lecturers, professors sharing lab space, and lab assistants that provided support and inspiration during the entire RET program.

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