Oscillators & Waves

IEEE ARIZONA SCIENCE LAB

www.arizonasciencelab.org

Workshop Focus and Synopsis:

This two-part workshop is based on an actual hands-on college-freshman physics lab, adapted for Grades 4-8.

In Part 1, using simple lab oscillators (pendulums), teams of three-students-each test hypotheses, learn about kinetic and potential energy, make measurements of pendulum period versus length, learn ways to reduce measurement error, graph their measurement data, and compare their results against Galileo's famous Law of the Pendulum. (See 1-minute video trailer at: http://youtu.be/OE_U4jDKoAc)

In Part 2, students explore how oscillators make audio waves, featuring hands-on demos of tuning forks, wine glasses, and soda bottles, as well as oscilloscopes and spectrum analyzers. Using a soda straw and scissors, each student makes his/her own class souvenir – a reed oscillator sometimes called the "Poor-Man's Oboe." Radio and light waves are also introduced through discussion and intuitive demos.

In a wrap-up class exercise, students apply their newly learned scientific vocabulary and understandings to their own descriptions of a twin-coupled pendulum demonstration.

Age Levels:

10-14 Years, Grades 4-8 (nominal)

Objectives:

- Execute a full "tour" of the four elements of the AZ / Next-Gen Science Standards Framework:

  Observe, Plan, Analyze, Communicate

- Practice observation and inference via close observation of a child on a swing (via video)
- As a class exercise, formulate and accept/reject 3 basic hypotheses about pendulum period through student measurements with stopwatches
- Learn about measurement error and the use of averaging to reduce measurement error
- In each lab team, measure and record data on pendulum period vs length. Graph period vs length and compare results to Galileo's Law of the Pendulum.
- Learn how oscillators like the pendulum can make audio waves. Experiment with tuning forks, wine glasses, soda bottles. Observe audio waves on the oscilloscope and spectrum analyzer.
- For each student, learn how to make a simple reed oscillator "oboe" from a soda straw and vary the pitch with holes punched in the straw.

Anticipated Learner Outcomes:

As a result of this activity, students should develop an understanding of

- Observation, conjecture, hypotheses and accepting/rejecting hypotheses via experiments
- Making measurements of time and distance, measurement error, error-reduction techniques
- Recording and graphing experimental data, making comparisons to expected results
- Oscillator period, frequency, and wave generation, including audio and radio waves
- Instruments for observing waves, including oscilloscopes and spectrum analyzers

Lesson Activities:

As a class exercise, students and instructor make free-form, intuitive observations of the forces at work when a child is pushed on a swing (pendulum). Using the instructor's lab pendulum, students practice using the stopwatch and meter stick to accept/reject 3 basic hypotheses about pendulum period versus displacement, mass, and length. Each team then works on its own lab pendulum to measure

period versus length, records and graphs the results, and compares results to Galileo's Law of the Pendulum. Students learn how tuning forks are like the pendulum oscillator and how they generate audio waves. They experiment with wine glasses, soda bottles, and the their own vocal cords as other oscillators that generate audio waves. The phenomenon of resonance is introduced. Finally, students construct their own souvenir – a reed oscillator made from a soda straw, and they learn how to vary the pitch of their soda straw "oboe".

Alignment to Curriculum Frameworks:

Note: All Arizona Science Lab workshops are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principals and Standards for School Mathematics. They will also be modified as necessary to be aligned to the Next Generation Science Standards (NGSS) when they are released.

Materials and Tools:

All materials and tools required for this workshop are provided by the Arizona Science Lab

Time Needed:

One four hour workshop (inclusive of lunch and restroom breaks).

ASL Staff Responsibilities:

The ASL staff is responsible for the conduct of the workshop:

- Setting up the workshop
- Presenting the lecture and teaching the science
- Performing the demonstrations
- Provisioning the materials and equipment to the student teams
- Supervising the construction project
- Supporting the students during the construction project

- Supervising the project testing
- Answering student questions about the science, the workshop, or any other related topic
- Cleaning up the workshop after the students have left

School Teacher Responsibilities:

- Managing the students during the class and the lunch and restroom breaks, and imposing discipline as necessary
    - The ASL staff is NOT responsible for the class management or for student discipline!
    - The restroom breaks will require at least one male and one female teacher be present from the school
    - Assisting the ASL staff in the teaching of the science. This could comprise asking the students questions about what had just been explained, presenting what had just been explained in another fashion, and so on
    - The ASL staff are not necessarily trained teachers and the school teachers know their students very well, so they can provide valuable insights and help to the ASL staff
- Assisting the ASL staff and students, during the lab measurements, data recording, and graphing.