

Welcome to Physics! Thank you for volunteering your time and sharing your talents.

**Goal:** The goal for this module is to learn some basic physics principles by having students participate in 2 activities. One is creating a PVC Tubulum and the other is designing/building a Marble Roller coaster.

Divide the students in half. One group will work on the PVC Tubulum while the other works on the Marble Roller Coaster. Once split in half, create 2-3 smaller teams to work on the activities. Midway through the module, have the groups switch to do the other activity. You will probably have about 10-12 minutes for each activity.

### **Introduce yourself and briefly share your career/education background.**

**Opening Comments:** Explain to the students that Physics is the study of matter, energy, space and time and the properties and interactions of these areas. Today they are going to work as a team to solve problems, develop a plan and execute an activity to demonstrate the principles of sound and energy.

Have at least one volunteer run each activity. Go over the activity with the students then give them some time to complete the activities, check their work and help as needed. Have the students switch activities about halfway through the module so each group has a chance to do both activities.

### **Activity #1: PVC Tubulum**

A PVC Tubulum is a musical instrument made using PVC tubes. The music is created by hitting the tubes of various lengths with a paddle (flip flop). See if any students have seen the Blue Man Group, they have an extensive PVC Tubulum they use to produce music. Another example of this is an organ that has various pipes to play the different notes.

First go over some of the physics in this project.....

- What is **SOUND**? Sound is simply vibrations in the air. Sound travels as a force that gets transmitted through air molecules with an initial push/force. Sound can also be described as a wave with movement like a Slinky.
- What is **FREQUENCY**? The measure of sound is frequency, it's unit of measure is a hertz (Hz), cycles per second. As air molecules are pushed/forced they bump into other air

molecules and then bounce back, this is done at a specific rate, frequency. Each musical note has a unique frequency. The higher the frequency, the higher the pitch.

- Students will use the **SPEED OF SOUND** to do a calculation. Speed of Sound is how fast sound travels through a given medium. Through air sound travels about 13,397.24 inches/second. This varies depending on temperature, elevation, and atmospheric conditions. Did you know that the speed of sound is faster in water, but is fastest through a solid material?

Next, the students will need to do some calculations and answer some questions to determine the PVC tube length for a given musical note.

- Each group has a sample piece of PVC. They are different diameters of PVC; one is 2", one is 1.5" and one is 1.25". Note that the diameter of PVC is measured for the inner diameter. The inner diameter will be used in their calculations.
- Also on each table is the Student PVC Tube Length Calculations sheet. Have each group of students fill out this sheet. They will check their PVC inner diameter, calculate the PVC length for the note of middle C and answer the questions that follow. For your information, the equation used for the calculations is.....

$$\text{Tube Length (in)} = \frac{\text{Tube Diameter (in)}}{2} + \frac{\text{Speed of Sound (in/sec)}}{\text{Frequency (Hz)} \times 2}$$

- You may help them with the calculations and adjust as needed. There is a Volunteer Answer Key to check their work.

Last, the students will play music.

- The tubes should already be placed in the board from left to right going from longest to shortest. The corresponding musical notes (letters) are on the board.
- They can use the tape measure to check the tube length for each note. There is a laminated sheet that shows the length of each PVC tube for the various notes. There is another spreadsheet at the table that converts fractions of a measuring tape to a decimal.
- They will use flip flops to hit the tops of the tubes and create music.
- They can use some of the songs provided or play their own music.

In summary, what happens is each time the PVC tube is hit, the moving particles are forced to vibrate a specific number of times per second. Changing the pipe length changes the number of vibrations. As the frequency of the notes increases, the tube length decreases, the wavelength decreases, and the pitch becomes higher.

**Talking Point:** What other kinds of instruments could we make to demonstrate sound/vibrations? A guitar could easily be made with wire or rubber bands; different lengths and tensions create different notes with a stringed instrument. There are numerous instruments out in the world, and all have their own properties for creating notes based on sound vibrations.

## **Activity #2: Marble Roller Coaster**

The students will be using PVC insulation, a yard stick, painter's tape, and marbles to make a roller coaster.

First go over some of the physics in this project.....

- A roller coaster uses two types of energy, kinetic and potential. **KINETIC ENERGY** is the energy an object has because of its mass and velocity (movement). **POTENTIAL ENERGY** is the stored energy of an object because of its state (mass) and position. Kinetic energy is relative to other objects in the environment while potential energy is completely independent of the environment. Kinetic energy can be transferred from one object to another such as in billiards, while potential energy cannot be transferred. As a marble (car) goes through the hills, loops, twists and turns of a coaster, its potential energy is converted to kinetic energy. Whenever it goes up a hill, it gains more potential energy with height but loses kinetic energy as it slows down.
- What is **CENTRIFUGAL FORCE**? This is a fictitious force that appears to act on an object rotating in a circular motion to keep that object on its circular path by pushing it outward. The loop of a roller coaster would be a great example of this. Can you think of other examples? A washing machine, a merry-go-round, curve of a road.

Now the students will use these laws of physics as well as trial and error to build their roller coaster.

- There should be a yard stick mounted on the side of the table. They will use this to create the downward slope of the coaster by using the painter's tape to tape the PVC insulation to the yard stick.
- Then using the painter's tape, tape the insulation periodically and add an additional piece to create a loop. Make sure to use the white cap at the end of the coaster so the marble doesn't roll away.
- The students can go through several iterations to create their roller coaster with the goal being to have the marble go through a loop without falling. The marble can be released from different points of the downward slope.
- Also, try using the steel ball instead of the marble. Is there a difference in the result?
- If time allows the students could create twists or add more to their coaster.

In summary, one question to ask is.....What factors determined if the marble made it through the loop? The starting point height versus loops height. The marble should start higher than the position of the loop. Also, the length of straight impacts if the marble makes it through the loop; the longer the straight, the less likely the marble is to make it through the loop due to increased friction.

**Talking Point:** Do you know what type(s) of career would be needed to design a roller coaster? The first is a mechanical engineer since they study and apply the principles of physics and material science as well as mechanical systems. You may also need a structural engineer to help with the

design of supports and an electrical engineer for lighting or electrical systems. Maybe an architect or landscape architect to give a little flair.

Please remove all the painter's tape carefully so we can reuse the insulation throughout the day. The tape may be thrown out after each group.

**End of the Day:**

- **JA staff and student volunteers will restock and pack the bins, so all items should be left on your table.**

**Thank you for making a difference today!**