



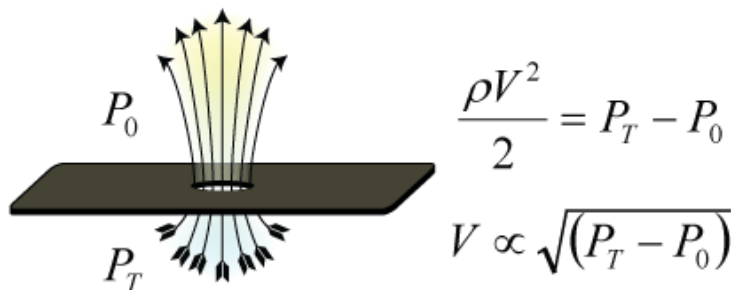
# Rubens' Tube

**Amount of time demo takes: 5-10 minutes**

**Don't try this on your own!**

## Lesson's Big Ideas

- Students will learn about how sound travels, standing waves, and properties of waves (ie. frequency, wavelength, speed of sound)
- Sound travels in waves and waves can interact with one another to cause amplifications and cancellations. Depending on the frequency chosen, we can make a standing wave of sound resonate within the tube; this is represented by the visible standing wave in the flames.
  - Flame height is proportional to gas flow.
  - Sound is a sequence of waves of pressure which propagates through compressible media such as air or water.
  - From bernoulli's principle- velocity of gas leaving the hole is proportional to the square root of the pressure difference



- Inviscid Flow Through a Hole.
- The distance between the standing wave peaks is the wavelength of the sound at that frequency.
- Using sound waves inside a tube, we can generate standing waves that are visually represented by flames. The various waves interact with each other to cause points of amplification and destructive interference: these are called nodes and antinodes.

## Materials

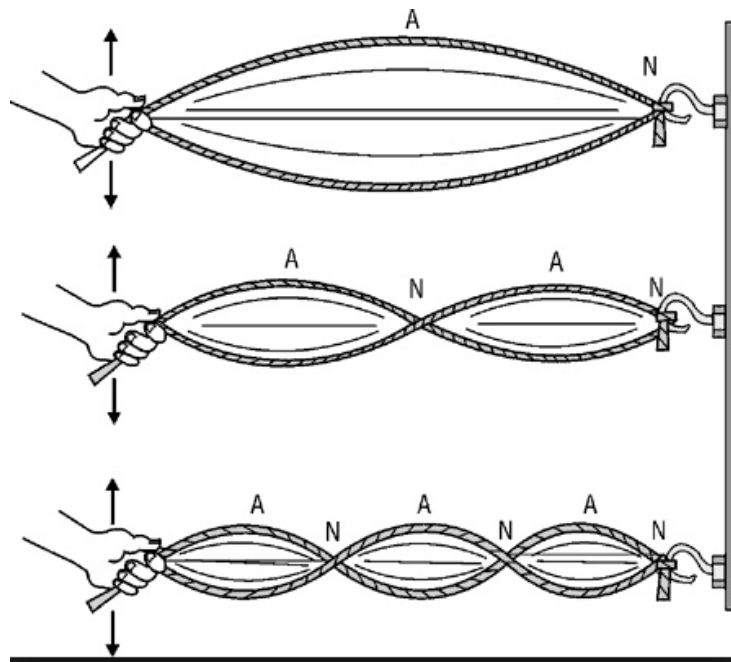
- Ruben's tube
- Gas regulator
- 20-lb or several 1 lb tanks depending on duration of demonstration
- Speaker
- Amplifier
- Aux Cord
- Extension cord for speaker
- Grill lighter
- Safety glasses, flame retardant gloves
- Two stands for the tube

### **SAFETY!**

- Safety equipment needed:
  - Safety glasses
  - Heat resistant gloves
  - Fire Blanket
- **Such a system has the potential to cause an explosion.**
- Tape a 3-ft boundary around the table this demonstration is on.
- **Fire is hot.** Don't allow spectators to come too close, ensure that you stand an appropriate distance from the tube, and remove anything flammable from the immediate area.
- Do a safety check of equipment throughout the day. If it cannot be fixed do not continue with the demo until it is working properly.

### **Background Information**

- Standing wave: a vibration of a system in which some particular points remain fixed while others between them vibrate with the maximum amplitude.
- Sound Propagation: Sound is a sequence of waves of pressure which propagates through compressible media such as air or water. During their propagation, waves can be reflected, refracted, or attenuated by the medium.
- Certain frequencies create a standing wave. In places where two high-pressure regions overlap we get constructive interference and the wave amplitude increases. Where high pressure encounters low pressure, we get destructive interference, and the wave amplitude can drop to zero.



### Setup Instructions

1. Place the Ruben's Tube on a level surface.
2. Attach the propane tank to the tube with the appropriate connectors.
3. Before each use inspect the integrity of the caps, connectors, and the hose barb to assure you do not have any undesired leaks.

### Instructional Procedure

1. Create a flow of propane into the tube. Moving along the tube with the lighter, set the gas at each hole on fire.
2. Generate a frequency that resonates with the tube.
3. Alter frequencies and amplitudes to demonstrate the changes in waves.
4. Regularly check that the speaker is not getting too hot, if the speaker feels too hot follow clean up instructions to shut down the demo and allow it to cool.

### Tips & Tricks

- Level the rubens tube to ensure an even flame.
- Place a block under the T connection to get the holes to face straight up.
- Playing music works well for gathering a crowd before starting the demo explanation.
- NEVER PICK UP BY COPPER TUBING.

## Assessment Questions

- How does sound propagate?
  - Waves of pressure
- What is a standing wave?
  - A wave where its peaks do not move spatially
- What do you think will happen if I change the sound that we put into the tube?
- What would happen if we were to play music into the tube instead of just one noise?

## Careers & Real-World Applications

- Chemical and Mechanical Engineering
- Noise Vibration Harshness (NVH) Testing
- Principles apply for water heaters and power generators
- Standing waves are used for ultrasound imaging

## Clean Up

- Stop the flow of propane into the tube and turn off the Speaker.
- Disconnect the propane and speaker.
- Allow the metal to cool.
- Take the tube outside if possible, and lean it lengthwise on a wall with the speaker end up. Remove rubber end. This will drain excess propane from the tube. After 15 minutes, the tube can be loaded into the truck *or* brought back in for another demo.

## References

- <https://www.che.utah.edu/outreach/module>
- <http://www.instructables.com/id/How-to-make-a-Rubens-Tube/>
- <https://www.youtube.com/watch?v=sQ3DCe5fziY>

## Related Next Generation Science Standards

- K-5
  - 1-PS4 Waves and their Applications in Technologies for Information Transfer
  - 4-PS4 Waves and their Applications in Technologies for Information Transfer
- 6-8
  - MS-PS4 Waves and Their Applications in Technologies for

## Information Transfer

- 9-12
  - HS-PS4 Waves and Their Applications in Technologies for Information Transfer