Rijke Tube

Demonstration

Number of Participants: 2 - 20

Audience: Middle (ages 11-14) and up

Duration: 5 - 10 mins

Difficulty: Level 3

Materials Required:

- Metal tube
- Wire gauze mesh
- Propane torch
- Burner lighter

A great example of resonance, heating up metal mesh placed in a pipe will cause the pipe will sing at a predictable frequency.

Setup:

1. Cut wire mesh to square slightly larger than diameter of tube.
2. Shove mesh about 1/5 of the way inside the tube. The tension against the pipe wall should be sufficient to keep it in place.
3. With assembly complete, all that's left is to play it! Turn on the flame and heat up the inside of the rijke tube until the mesh turns cherry red. When placed vertical, the pipe will sing, until the mesh cools, typically about 10 seconds.

Figure 1 Mesh inside tube.

Figure 2 Light the propane, heat up the mesh in the tube, and hear it sing (as long as the pipe is vertical).

Vocabulary:

- Longitudinal waves - waves with excitations parallel to their direction of propagation, e.g. sound waves.
- Node – the point in a wave where there is no motion.
- Anti-node – The point of a wave with highest amplitude. For the tube, the highest flames are in the anti-nodes
- Convection – heat transfer by the bulk movement of molecules (here, air).
- Resonance – a condition where large amplitudes of energy (here, sound) are created by smaller excitations at the natural frequency of the system.

Physics & Explanation:

Middle (ages 11-13) and general public:

Changing the temperature of the air changes its pressure, and sound waves are just changes in air pressure that our ears pick up. By heating up the mesh in the tube, how the air around the mesh will warm as well, and excite the pipe into singing as air starts funneling up through the tube, being warmed by the mesh. The pipe will continue to sing at this one pitch until the mesh cools off again.

When you turn the pipe sideways, even if the mesh is red hot, the tube will not sing. The hot air will just get stuck along the top of the pipe without being able to move in or out of the pipe. Also, the pipe won't sing (well, if at all) if the mesh is on the top half of the pipe. It takes too long for the air to reach the mesh and it won't have very much room to move up the pipe before coming out of the pipe.

🔑 Hot air has to be able to move up through the pipe to excite it and sing.

> Explore different ways to do the demo. How could you make the tube sing louder? Sing at a different pitch?

Moving where the mesh sits can change the amplitude of the sound, because there are more optimal placements than others (somewhere between the middle and end is optimal, e.g. about 1/5 or 1/4 up the pipe). Moving the mesh however will not affect the pipe's frequency it sings at. The pipe will also sing louder the hotter you can heat the mesh.

In the same way that you can't play multiple frequencies when playing a piano or organ pipe, there's nothing you can do differently in heating up the pipe to change it's frequency, except change the pipe's length. The shorter you go, the shorter the wavelength, and the higher the frequency will be played.

🔑 The particular sound frequency the pipe plays depends on the length of the tube.

Highschool and up (ages 14+):

Changing the temperature of the air changes its pressure, and sound waves are just changes in air pressure that our ears pick up. It's the discrepancies of pressure between room temperature and the hot air that passes through the mesh that excites the pipe into its resonant frequency.

🔑 By means of convection, hot air rises and "sucks" air up the tube to excite the pipe to resonate at its fundamental frequency

What pitch, or frequency, will the tube sing at? The resonant frequency can be determined with first year physics equations:

$\lambda = 2L$ for the fundamental frequency the pipe will sing at, and $v = f\ \lambda$ where v is the speed of sound. Solve for f.

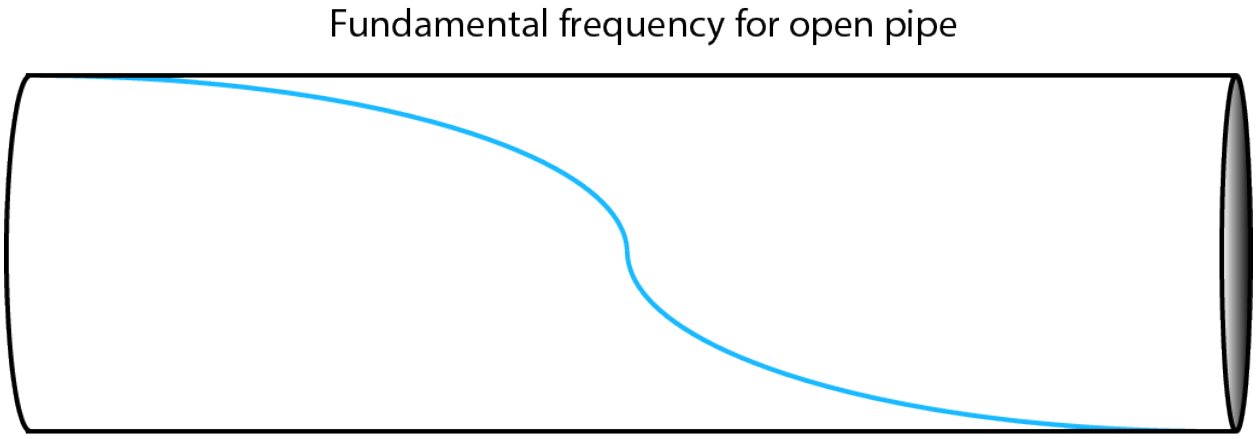

Figure 3 For a pipe opened at both ends, the fundamental frequency is 1/2 the length of the tube.

Sound can be "poured" in or out of the tube. Tilt the pipe sideways to pour the hot air as the pipe sings into a cup, and then pour the cup back into the pipe to begin singing again.

Additional Resources:

- Rossing Moore & Wheeler, *The Science of Sound* 2002.