Acoustic resonance in a loo roll

(exp. id 20210107-1-v1)

An experiment proposed by:
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Overview

This experiment demonstrates the acoustic resonance in a tube. Every day objects can be studied: loo rolls, coffee mugs, glasses, ...
Using a smartphone, you will investigate how well a sound can exit from a tube. To do so you will generate a perfect pitch and tune the frequency looking for a maximum. The physics behind is resonance: some frequencies will match the shape of the tube better than others and will produce a stronger sound. This is also the physics behind wind instruments such as the flute.

Materials & Requirements

1. A smartphone with *phyphox* installed;
2. an earphone with microphone;
3. a tube, either opened at both ends (such as a loo roll) or opened at one end only (such as a glass).

Making the experiment

This experiment uses the audio record of the smartphone, which will be available on all smartphones. The principle is to plug the earphone to the smartphone, and to use one earbud as a small speaker. The earbud is placed inside the tube. The microphone of the earphone is kept outside the tube and will record the intensity of the sound exiting the tube.

Produce a pure sound at a given frequency and measure the sound intensity. Change the frequency and look for a maximum: can you hear it?

The easiest way to look for this resonance is to use the application PHYPHOX with the experiment “acoustic resonance”. This experiment is not included by default, and you should add it to your collection through the following QR-code:

Just click on the "+" icon on the lower right corner and select "add experiment from QR-code". Scan the code and add the corresponding experiment to your collection.

Clicking on the small pulsing triangle on the top right of the display (start button) the sensor starts sweeping the frequency automatically. You can choose the starting frequency, the step (F_s) frequency and the frequency factor (FF): each second a new frequency f_{i+1} is measured, calculated from the previous frequency f_i following the equation:

$$f_{i+1} = (f_i + F_s) \times FF$$

Prepare your experimental: choose the object you want to investigate, position the earbud and the microphone, and run the experiment. Choosing the right settings may require some tries, in order to obtain a curve that displays an acoustic resonance, i.e., a peak in intensity.

General remarks

As in any acoustic measurement, a quite environment is a necessity. Look for some peak: they indicate the resonance. The sharper, the better. The position of the earbud may influence the results. Consider what these data mean.

For the instructor

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This activity was inspired by an experiment described on the Internet, with earbuds in a stack of loo rolls (e.g., `https://www.npl.co.uk/measurement-at-home/measuring-sound-using-toilet-rolls`). The physics however is not exactly the same: the latter activity uses interferences between the two earbuds, the loo rolls only serve as a conduit for the sound, whereas in the proposed activity here, it is the acoustics of the tube that is tested.

A description of the model can be found on Wikipedia `https://en.wikipedia.org/wiki/Acoustic_resonance`. The experimental results may differ from the model, since the latter contains some assumptions and simplifications. It can be a good starting point for a discussion with students on what a model is.

Objectives, Level of deployment, and Duration

1. Primary objective: Enjoyment and practice in empirical experiments.
2. Primary objective: Development of scientific investigating skills.
3. Primary objective: Obtaining data that can be plotted and fitted, without requirement of much analysis.
4. Suitable for: high school and university.
5. Duration: no more than 2 hours of data acquisition, + 1 hour of data plotting, + writing short report.

Further Info Online

Please leave feedback, suggestions, comments, and report on your use of this resource, on the channel that corresponds to this experiment on the Slack workspace "smartphysicslab.slack.com". Instructors should register on the platform using the form on `smartphysicslab.org` to obtain login invitation to the Slack workspace, and/or to request being added to the mailing list of smartphysicslab.