James Dyson Foundation Undergraduate Bursary 2022-2023

Outreach activity summary: Playing plastic bottles

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Figure 1: Inspiration taken from footnote 1.

Activity overview

My Dyson Day activity was to create an instrument out of plastic drink bottles to introduce students to acoustical engineering.

Introduction to acoustical engineering

I particularly wanted to highlight that although acoustical engineering is involved with more 'classical' or 'stereotypical' notions of engineering (e.g., in aerospace), it is very wide reaching; it has exciting applications in biomedicine (which is being pioneered in the CUED Acoustics Lab), and it is also a discipline which answers questions about everyday things.

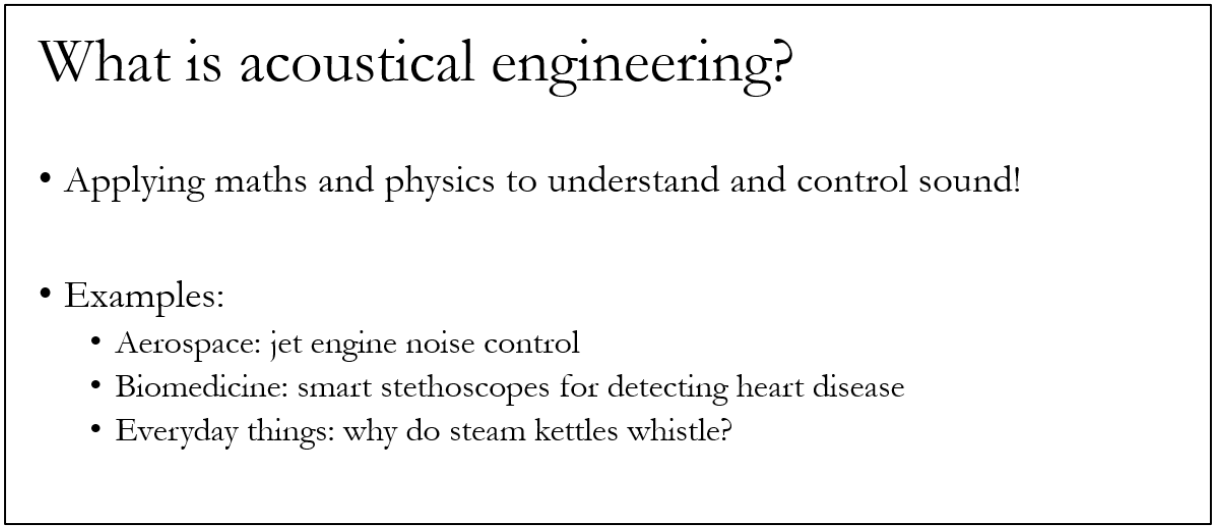

Figure 2: Slide used for introduction to acoustical engineering.

The physics behind the instrument

I then introduced the activity for the day which was inspired by various videos on YouTube[1] [2] [3]. Essentially, the activity was to ask students to drill a small hole in the cap of a plastic drink bottle to be able to insert a bike valve and then pressurise it using a bike pump. At different pressures, the bottles will produce notes of different pitches.

Before embarking on the activity, I explain the physics behind why this instrument works. I ask students to consider how a bottle is capable of making a sound in the first place (what creates sound?). This is a seemingly basic question, but it is clearly fundamental to understanding how the instrument works. I think it goes to show how we take many everyday things as given, and that there is actually a lot of physics and maths in everything that we see. After getting some close guesses from students, I give an explanation and show the first mode of vibration for a plastic bottle.

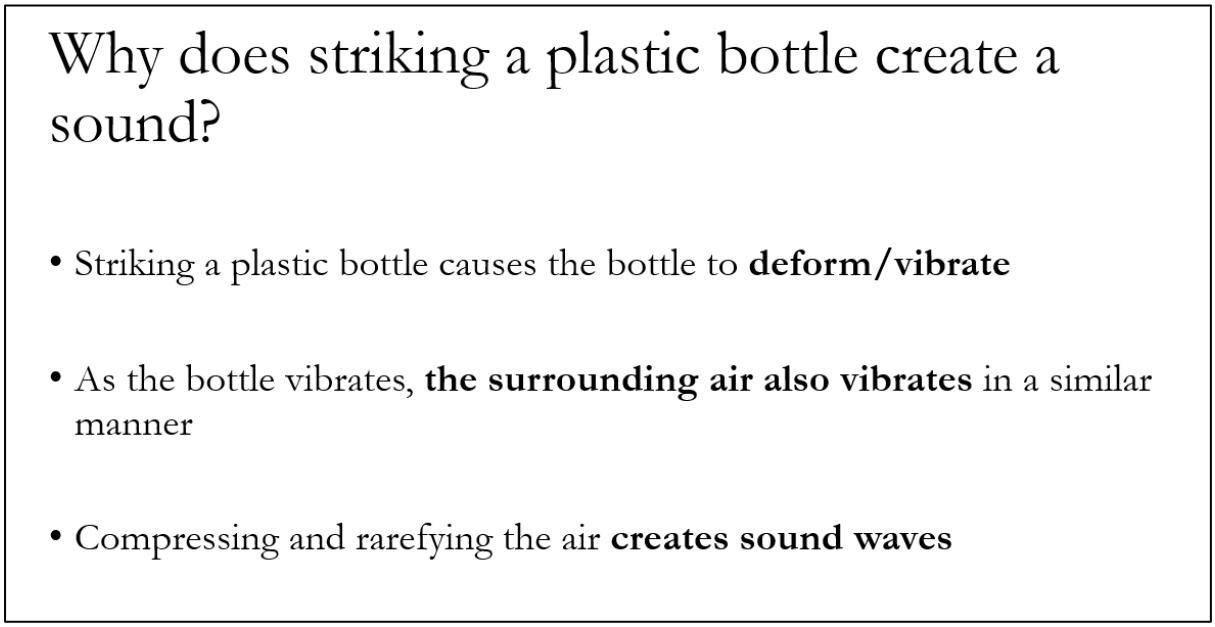

Figure 3: Explanation for why a bottle can create a sound when it is hit.

I then ask why changing the pressure of the air inside the bottle changes the pitch of the note the bottle produces. Through this, I introduce the concept of the natural frequency, and briefly mention how Rayleigh's principle is used in determining the resultant pitch. I leave this explanation to be quite brief, but try to get across the idea that energy conservation is involved, because this is a concept the students are familiar with, and crops up time and time again in all places in engineering.

[1] https://youtu.be/T0C5PnCID10
[2] https://youtu.be/koIC_MAB3MU
[3] https://youtu.be/CdWnUi8PVfs

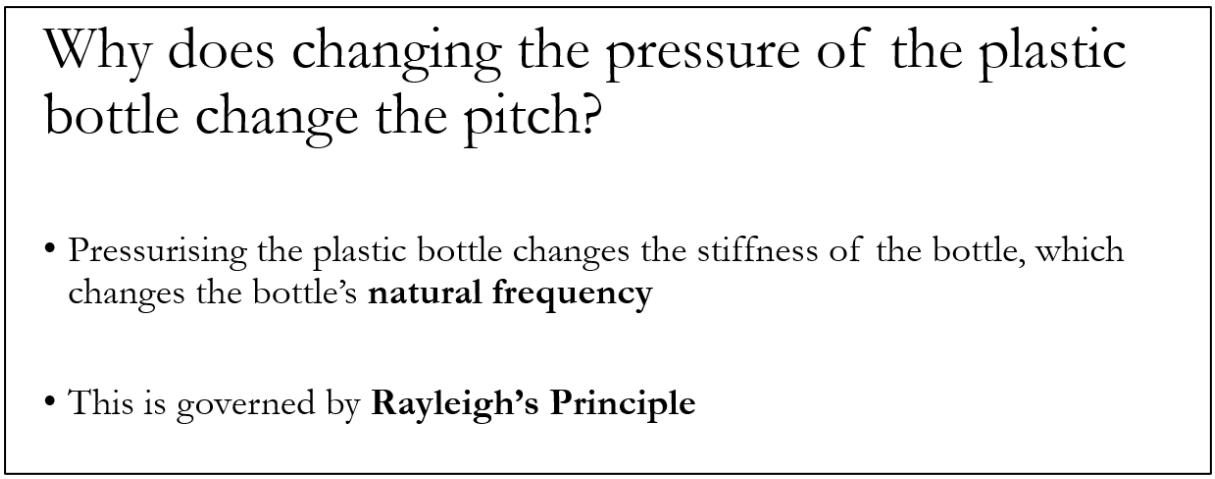

Figure 4: Explanation for why the pitch of the bottle will change when pressurised.

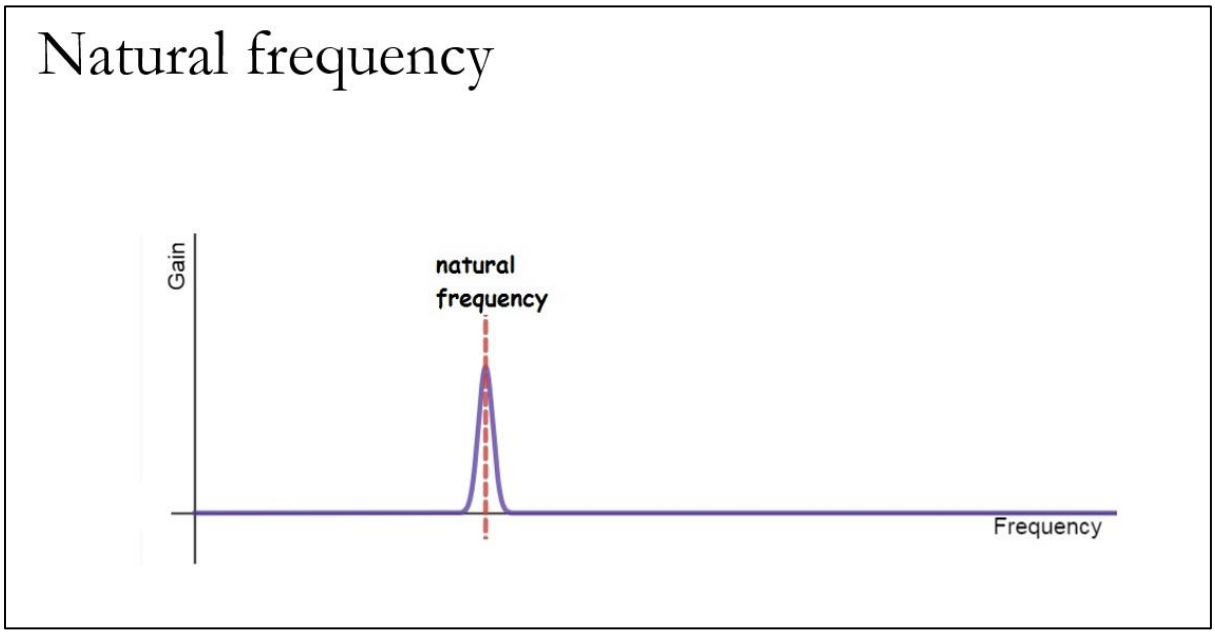

Figure 5: Introduction slide for the concept of the natural frequency.

The activity

After explaining the physics, we get started on the activity. I had collected many plastic drink bottles leading up to the Dyson Day, and the other main pieces of equipment were bike valves, hand drills, and bike pumps. Safety goggles were worn when pressurising the bottles. I also had an app on my phone which could be used to tune the bottle's pitch.

Students were quick to work, and while some were busy attaching the bottles to a wooden pole to create the instrument, I showed others a Caribbean steel pan drum as another example of acoustical engineering. I explain that what is very impressive about a steel pan drum is that a single sheet is able to create different tones (unlike the bottles, which were one tone each). I show them a map of the notes on the steel pan drum and I let students play about with the instrument and ask them to consider what the different modes of vibration might be for a steel pan drum.

Figure 6: Final bottlephone on the day.

Figure 7: Steel pan drum (left) and me trying to learn how to play it before the Dyson Day (right).