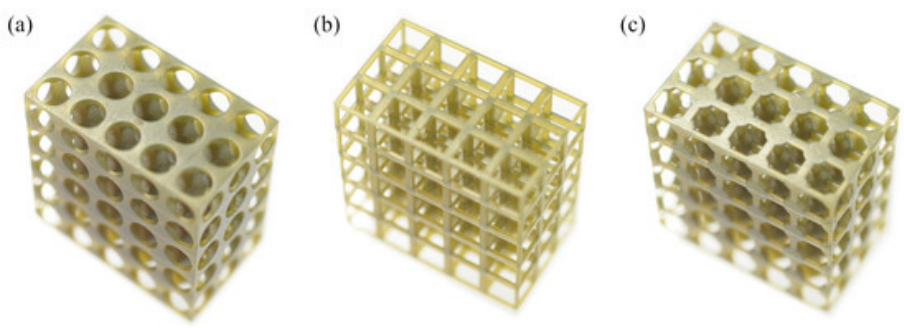
Science MATTERS! ... IN CONNECTICUT
Science Matters! is a series presented in collaboration with the Connecticut Academy of Science and Engineering.
*For more information, visit **www.ctcase.org** or **call 860.571.7143**.*
NIE ACTIVITY

CONTROLLING SOUND

We can manipulate fire, electricity, magnetism, and light. Next up is sound.

Richard Dube, Senior, Glastonbury High School

Loud sounds cause hearing loss over time, which affects pilots, active service members, and musicians, as well as many others. For most of these cases, a simple noise-canceling headset can prevent hearing loss. But, noise-canceling headsets have certain downsides. They need power, are expensive, and block out loud sounds and even the quieter ones that the individual might need to hear.



Lucklum, Frieder; Vellekoop, Michael J. 2017. "Design and Fabrication Challenges for Millimeter-Scale Three-Dimensional Phononic Crystals." Crystals 7, no. 11: 348.

My research project seeks to find the best **phononic crystal** for noise cancelation. Ideally, these devices would not have the downsides of noise-canceling headsets. It would be cheap and easy to produce via 3D printing; no batteries or other forms of energy would be needed. Instead, the device would rely on a clever combination of material properties and design features. Finally, it would allow quieter sounds to pass through while reflecting loud sounds. These benefits allow the product to be used in a variety of situations.

Since we know that these crystals can perform the tasks we'd like it to, my research focuses on optimizing the material and structure of the crystals. My first step was to develop a model to describe waves moving through the crystal. I developed my model using **Hookean springs**. The advantage of this model was its flexibility, since I could simulate any material with it.

Using this model, I will next use **COMSOL Multiphysics** to simulate sound moving through different structures. By changing certain values in the model, I can simulate different materials. Different materials introduce different amounts of friction. By changing the material used, we can change how much quieter the sound gets. However, changing the material also changes the mass and operating frequency of the crystal. Using the program, I can find the best material and structure for the application of noise-cancelation. Sample crystal structures that may be tested are shown in the image.

I will choose the best properties based on cost, operating range, effectiveness, ease of production, and durability. Once I optimize the properties of the crystal, I will send them to an experimental group, who will create a physical product.

When I finish this project, noise-cancelling devices could be more personalized. By changing the operating frequencies or how much friction there is, we can satisfy different needs. Phononic crystals can be catered to anyone frequently exposed to loud sounds. Then, we could say we successfully controlled sound.

Meet the Scientist

I am a senior at Glastonbury High School, and this is my second year conducting research in Physics. My junior year, I worked with the GlueX Collaboration to identify particles that they created in their production chamber. This work helped determine if the Standard Model, which describes the world smaller than protons and neutrons, is accurate. Part of the Standard Model is the mechanics of propagating waves, which attracted me to my current project. In my free time, I also enjoy maintaining reef-themed fish tanks, which include keeping marine invertebrates and corals.

SKILLS & KNOWLEDGE

Because this project is heavily based in mathematics, I had to learn some calculus concepts like derivatives and differential equations to develop the model. I also used Python programming language to develop various charts and plots of my simulated data. In the final part of the project, I will need to learn some technical skills to use COMSOL Multiphysics® to model the specific physical problem.

hyperlinks

http://phet.colorado.edu/en/simulation/normal-modes
http://hyperphysics.phy-astr.gsu.edu/hbase/oscda.html
https://electronics.howstuffworks.com/gadgets/audio-music/noise-canceling-headphone3.htm

Words To Know

Phonon: A cluster of sound waves

Phononic Crystal: A material that only certain sound waves can pass through. Only waves of certain frequencies or amplitudes can

Hookean Spring: A spring that exerts a force which has a strength proportional to the compression or expansion of the spring

COMSOL Multiphysics: A software for simulating different physical problems using a programmed model.

Damping: The process of making a sound quieter

For Students and Teachers Making Curriculum Connections, see the following:

NIE NEWS IN EDUCATION

Connecticut State Department of Education (CSDE) - Common Core State Standards (CCSS): Mathematics

- CCSS.Math.Practice.MP1 Make sense of problems and persevere in solving them
- CCSS.Math.Practice.MP3 Construct viable arguments and critique the reasoning of others
- CCSS.Math.Practice.MP5 Use appropriate tools strategically

CSDE - Next Generation Science Standards: Scientific and Engineering Practices

- Asking questions and defining problems; developing and using models; planning and carrying out investigations; analyzing and interpreting data; using Mathematics and computational thinking; constructing explanations and designing solutions; engaging in argument from evidence; and obtaining, evaluating, and communicating information.