I wanted to explore a fundamental force of nature and intentionally let it affect and create a piece of art. I chose to work with gravity and made a harmonograph; a simple machine that uses pendulums to draw geometric figures. I used a door hung parallel to the ground to make a lateral harmonograph, with a stationary plank of wood extended over it that could hold various tools for drawing: a paintbrush, a marker, a funnel full of paint. When pushed, the board swings in a lissajou curve. The markers made the most predictable patterns unless someone interfered and changed the position of the paper or the color of the marker. Charcoal required constant observation and influence for uninteresting and predictable results, so it was essentially a more tedious version of the marker. The ink was similar to the charcoal - I found it to be a fickle medium, and the results diverged far more than the previous mediums. It reacted to water and salt creating even more geometric patterns, but it was unpredictable and I would constantly have to intervene or plan ahead carefully in order to create a piece where the lissajou curve was still visible. Acrylic paint took the most effort to set up, but it was also the most autonomous medium. For four of the paintings, paint was poured on the board, and for two it was dripped through a funnel. Paint had the most variables (viscosity, color, layer) as well as the most interesting results that were probably the closest I got to my aforementioned ideal.

I still have a desire to methodically create every possible outcome, and enjoyed the process of experimentation.

Lauren B.
California

Fundamental Interactions

Lauren B.

I wrote this paper with the end goal being the art I would create. With this in mind, I chose three "invisible" forces - vibrations and pressure, magnetism, and gravity - that have a physical influence over tangible objects. In the following paragraphs I summarize the research I did on the topics and how they would translate into art.

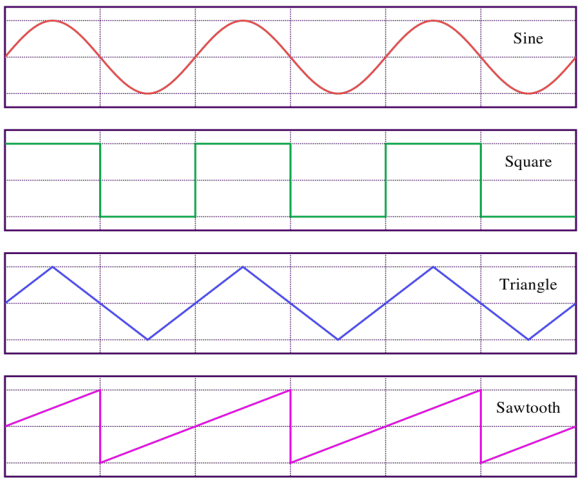
Growing up in the "Age of Information", with engineers for parents, I was basically raised to be interested in STEM. STEM, an acronym for science, technology, engineering, and math, is basically just a name for the subjects that aren't the humanities. I didn't want to be a scientist or an engineer, I was more interested how I could create with that knowledge, and seeing as my "childhood show" was Mythbusters, this was the logical conclusion for me to make. Coincidently, there was a simultaneous push to include art courses in STEM making it STEAM. This was done because creativity and innovation go hand in hand (also art classes were being marginalized and underfunded). I understood this as the acknowledgement of fields where STEM and art overlap- which includes but is not limited to: objects made to be functional with aesthetic in mind, like architecture and industrial design, or as digital arts like photography, film, and digital drawing- the additions of art to science or using science as a new way to make new art. There is plenty of art to represent math, technology, and engineering, but it is rarer to find science as the focus of the art. For example: a robotic spider, the subject is a piece of technology, the process was engineering and math. For science to be art, science would have to be the subject or essential to the process. While one could argue that science is represented in those pieces, because all technology must include science at some level, like a battery or a lightbulb is chemistry, a battery would not be considered art and is hardly the centerpiece of any robot. I consider science to be a beautiful thing: chemical reactions, microscopic imaging, pictures of space, and seeing how all these things are connected. However, I consider art to be something made with the intention of it being art. Just

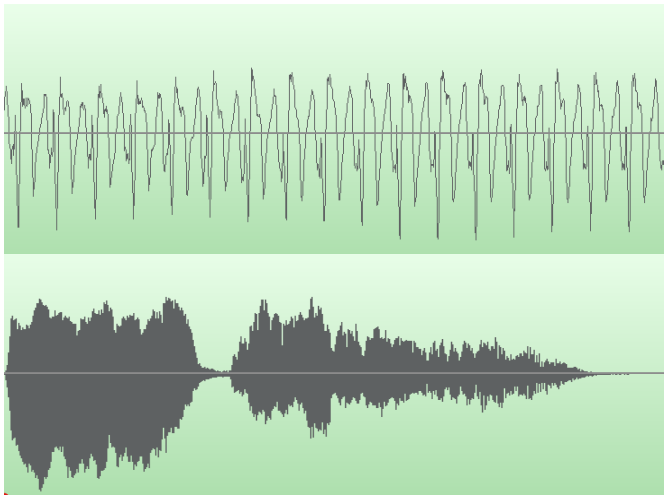
because something is beautiful, made intentionally, or made intentionally beautiful, does not make it art. The creator must make a conscious decision that they are going to make art. If you are were inventing a lightbulb the intention to make a lightbulb but then changed your mind halfway through, stopped recording your findings and presented your finished light bulb not as a scientific breakthrough, but as a piece of art, then in my mind, it counts. For this project I wanted to either create art with the scientific process or create art that contains science. I wanted to create a chemical or physical reaction in which the production of art would be the secondary outcome. The art being the product of a reaction where I only act as the initiator. Can I make the laws of nature make art for me?

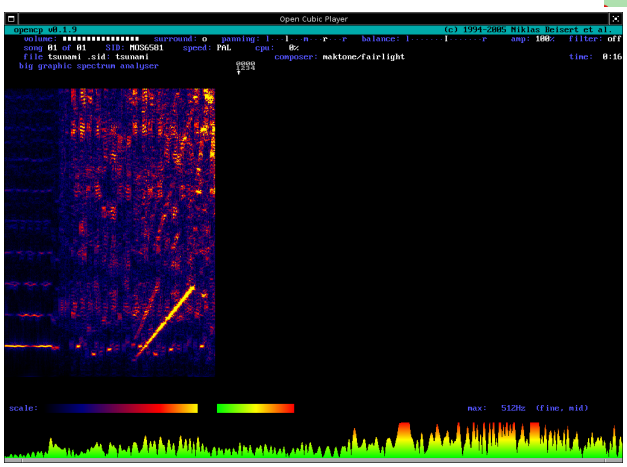
Sound was the first physical force that I considered using. Humans associate sound with an image. We have also figured out a way to share sound and to preserve sound by associating certain sounds with alphabets and musical notes. We look at a picture of lines and dots and are able to understand what it tells us to do. While a human can read notes, a speaker can't. The waveform of a song is a graph of the amplitude over time. Sound waves are a series of compressions and rarefactions. A speaker makes these waves through a magnet that moves back and forth. The magnet is controlled by an electromagnetic field; when the direction of the current is switched the poles of the electromagnet switch, and with it the direction magnet is attracted to is switched. The waveform shows the time between each compression (the frequency or pitch of a sound) and the amplitude (the volume), which are caused by a change in voltage. It tells the computer in binary logic how to play a song. However, it's still nice to have a picture that a human can understand, and it is easy to get one using one of the many available visualizers; programs that generate animated images based on the waveform of a song in real time. Visualizers are a more mathematical representation of sound. While they can create images that appeal to people, they

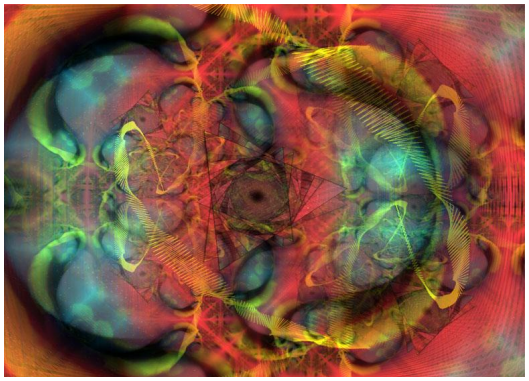
are basing the image off of the amplitude and the volume. They do not interpret sounds like humans do. A song in minor key might be darker, but the program wouldn't recognize that; a song with an electric guitar and an acoustic guitar would be viewed differently to a human, but not to a computer. Because of how rigid these algorithms are, some people have manually made visuals for sounds. Music videos are the most common example.

There are also versions of fine art created by chromesthesia synesthetes, people with synesthesia who, when hearing a sound, simultaneously experience or associate sight ("Chromesthesia"). A few noteworthy artists are Carol Steen and Melissa McCracken. Their paintings show more variety between each piece, compared to synthesized ones. Not only does synesthesia affect every person differently, but they are also influenced by more variables than a

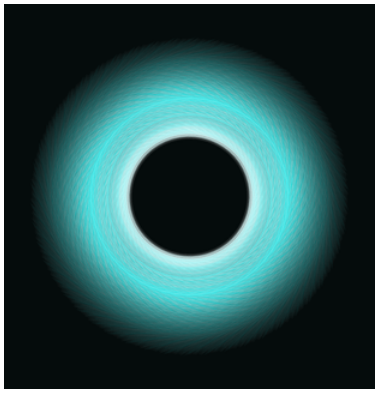


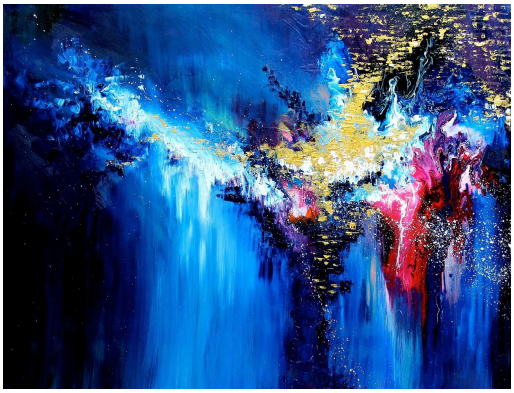






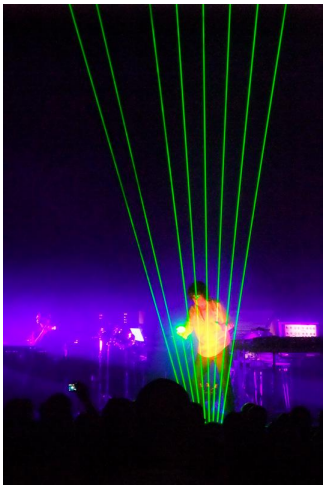
visualizer. They are not limited like a computer, because the human ear can focus on certain sounds and the human brain is capable of identifying and tracking different sounds. There are also a few instruments that combine the visual with the instrument; like the color organ or the laser harp. All of these are example of humans acting as the middleman between sound and image.





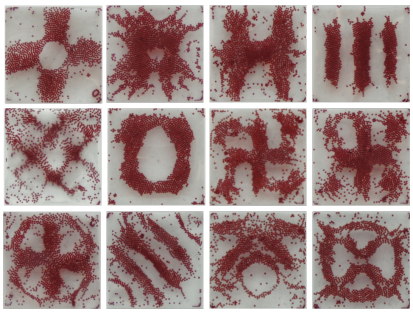
Sound and vibrations can already make a physical mark; why do people have to go through so much effort translating it into images, when sound already has its own version?

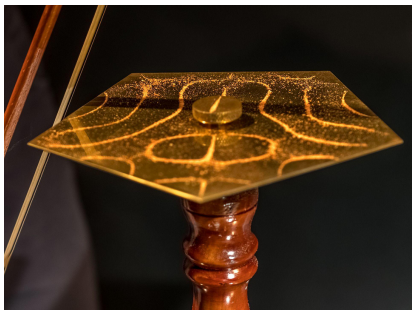
Cymatics is the study of waves and their visual representation. One example is Rubens' tube, where a perforated tube connects a propane tank and a speaker. The sound wave travels through the gas creating points of higher and lower pressure. More gas is pushed out of the areas with higher pressure and vice versa. When lit on fire, the pressure nodes become visible, displaying the wavelength. Faraday waves and Chladni Figures are both examples of nonlinear standing waves in respectively liquids and solids. Chladni figures are made by putting powder on a resonating plate or membrane. The powder is moved by the vibrations into the places that don't vibrate. I would like to use this method



to move rosin dust on a copper plate to make aquatints in printmaking.

Magnetism interests me because it feels the most tangible. Pushing together two magnets of the same pole, you can feel the magnetic field. I want to make that force and its influence visible somehow. By mixing magnetic sand with powdered pigments or with paint and exposing it to a magnetic field. I think that there is potential with this method but I also worry that it would just end up looking like a bunch of smudges because of how heavy and immobile the sand is, and I want the focus of the art to be the magnet's influence, not gravity's.





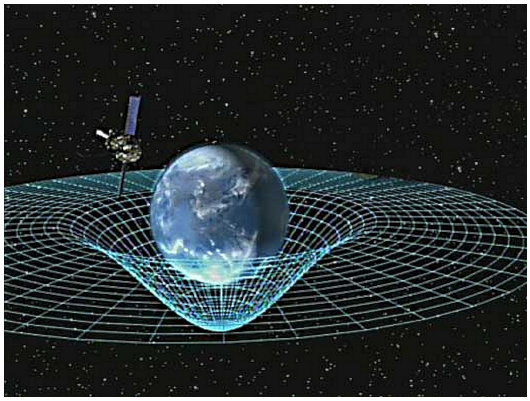
I am also extremely interested in Ferro fluid, a ferromagnetic (reacts to but doesn't produce a magnetic field) fluid. I first saw it when I was around 13 at the National Museum of Nuclear Science & History. While Ferro fluid was originally invented as an anti-gravity proof rocket fuel, there are plenty of people who use it for other things. Sachiko Kodama makes mesmerizing sculptures and Fabian Oefner did a series of photographs called Millefiori were he mixed watercolors with Ferro fluid. It bothered me that these unique instances could only be captured in a photograph. I'm interested in using Ferro fluid as part of the process or medium, instead of displaying it as the subject of the art. The patterns it makes are an awesome combination of the magnetic field, aurora borealis, and surface tension.

Ferrofluid can be mixed with ink depending on the ink's composition as well as what is used as the surfactant (the liquid used to lower the surface tension and prevents clumping), but by doing so the Ferro fluid would be able to leave marks. Another possibility would be putting it in liquid in or watercolor. The most interesting figures are made when the Ferro fluid is pressed between two pieces of glass and then magnetized when Ferro fluid is magnetized it is not at all flat, so you can take away one of the pieces of glass, and when Ferro fluid isn't magnetized it just acts like oil.

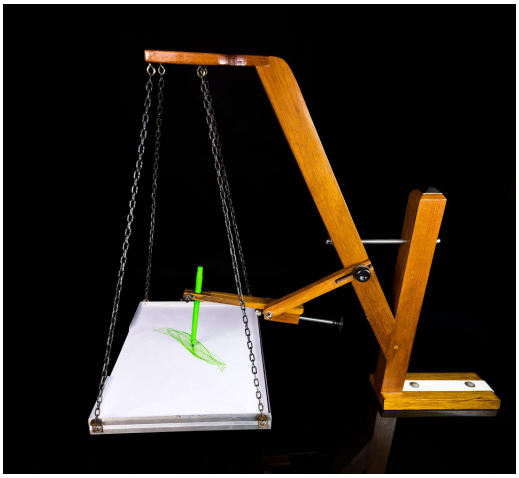
There would be no way to transfer the pattern. That means that I could put it on the 'canvas' and then place the glass over it, so that all the movements it makes would leave a mark, or I could magnetize it first on the glass and then put the 'canvas' over that, which could just end up looking like a bunch of inkblots.

There are four forces of nature, gravity, electromagnetism, strong nuclear forces, and weak nuclear forces. Gravity is the only other force that didn't cost a lot or include a ton of dangerous materials. The space-time model is a mathematical model that combines three dimensions of space and one dimension of time into one four dimensional continuum. It is used to demonstrate relativity- how an event is perceived based on where and when it occurs relative to the observer. In Einstein's general theory of relativity, forces of nature can warp the space time continuum. There are demonstrations of this effect, where there is an elastic material stretched over a ring with

spherical weights of varying mass and size are pushed or placed onto it, and I thought of recreating this but with paint covered weights. The paint and background could mimic the colors of real celestial structures. I am really interested in space-time, but I only have the ability to depict gravity's effect on three dimensions so I focused on what I could depict; gravity's effect on trajectories, orbits, and pendulums.



The harmonograph is a drawing machine that uses pendulums. I would make a single pendulum harmonograph. The pendulum being the board hung separately by its four corners. The stationary marker captures the boards movements, which are slowed by the friction of the marker on the paper. If I were to set up a funnel filled with paint as the marker, there would be no friction, as a result the lines would be closer together. It would be fun to experiment with different markers as well as how the strings' positions to see how they affect the harmonograms.



The harmonogram was simple and inexpensive, so I ended up making one. It is a single pendulum harmonograph so it can only make one figure, a lissajous curve. It's three feet by six feet and it hangs from four nine foot strings. I made the board the pendulum instead of the marker the pendulum because a marker pendulum can only use powder or liquid as a marker, but with the board pendulum, the marker can be a pen/brush or a powder/liquid. I can also switch out the marker or pour more paint into the funnel in the middle of a drawing. I have a plank of wood with a hole in it at the end. There is a screw that I can use

to clamp the marker/brush into the hole. The plank is made out of a semi-flexible material so that when the board rises and falls slightly, the marker can track it. The period of its swings is fast enough that the lines are spaced out enough to have definition even in messier mediums, and the widest is around two feet. I started by using markers, and it took me around four hours before I got a decent figure. By letting the marker sit loosely, there was less friction and I got more iterations per shape. When there was more friction, the marker would jump, making a dashed line. Markers were the most flexible and predicts medium; I was able to layer them and could control the outcome which made me think about color palettes and composition. Ink, water, and salt were much harder to control, but the result had much more variety. Gravity had a more visible effect on the ink harmonograms. I used a calligraphy brush so the pressure on the brush shows nicely in tapered lines. There are some instances where the water would drip on the paper, leaving trails. When the paper is wet it gets warped, the ink and water pools in certain areas. Depending on how much water is in the ink, the pools dry in a gradient. Paint was the last medium I used, and was the most unpredictable. It is the best example of letting natural forces make the art. I could choose when a piece was finished, but even after that, the paint might crack or move. I would act as the catalyst to the production of these pieces, but I had no influence over the process or the result. As the most mercurial medium; paint was the most successful for letting gravity make art for me.

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