

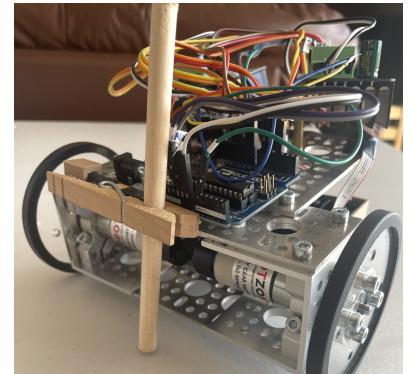
The following are some of the projects that I've worked on. The first two pages have mostly physical projects, while the second page contains CS-focused creations that can be found on my website, <https://hafnium780.github.io/>.

In Aspiring Scholars Directed Research Program, I wrote and published a paper on the runtime with my group of three:

Pan, Michelle, Vaibhav Vaiyakarnam, Allen Li, and Larry McMahan. "Impact of carbon number and atom number on cc-pVTZ Hartree-Fock Energy and program runtime of alkanes." *Journal of Emerging Investigators*, March 6, 2024. <https://doi.org/10.59720/23-130>.

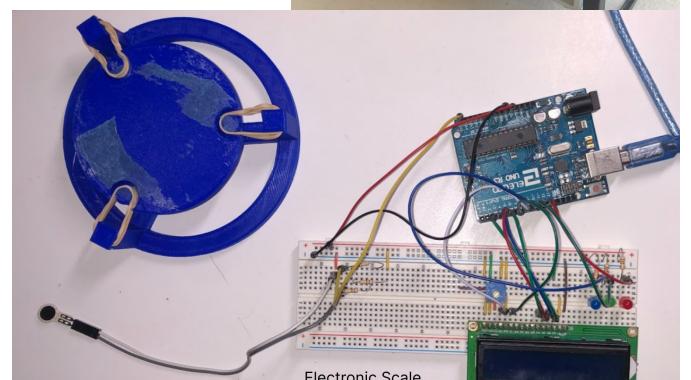
**Robot Car** - A small DC-motor powered car that navigates a grid-based maze for Science Olympiad.

The car uses odometry based on the encoders on the motors, which allow the car to travel precise distances through the maze and end as close as possible to a target point, while accurately controlling the time it takes.



**Electronic Scale** - An electronic scale using a force-sensitive resistor for Science Olympiad.

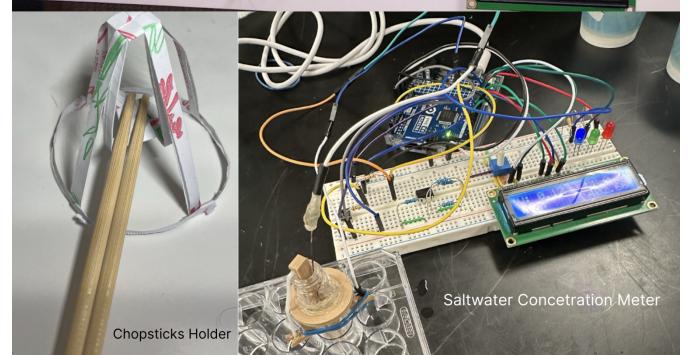
A voltage divider and Arduino work to measure the resistance of the force-sensitive resistor, which is used to compute the weight of the object placed on the stand I designed and 3D-printed.



**Chopsticks Holder** - A chopsticks stand folded using only the single wrapper around a pair of chopsticks.

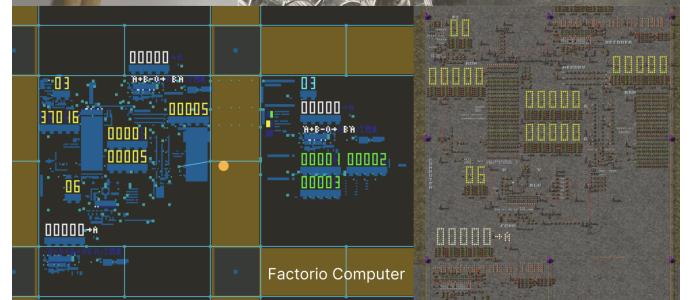
**Saltwater Concentration Meter** - A device that measures concentrations of salt in water, using oxidation-reduction potentials for Science Olympiad.

Based off the electronic scale circuit, I designed parts to fit around a glass tube, which holds a potassium chloride solution and serves as a reference solution to which the saltwater is compared.



**Factorio Calculator** - A 16-bit computer constructed in the video game Factorio, computing the Fibonacci sequence in the left image.

Built using only combinatorics (the game's equivalent of logic gates), I based the computer architecture off my learnings from [NandGame](#).



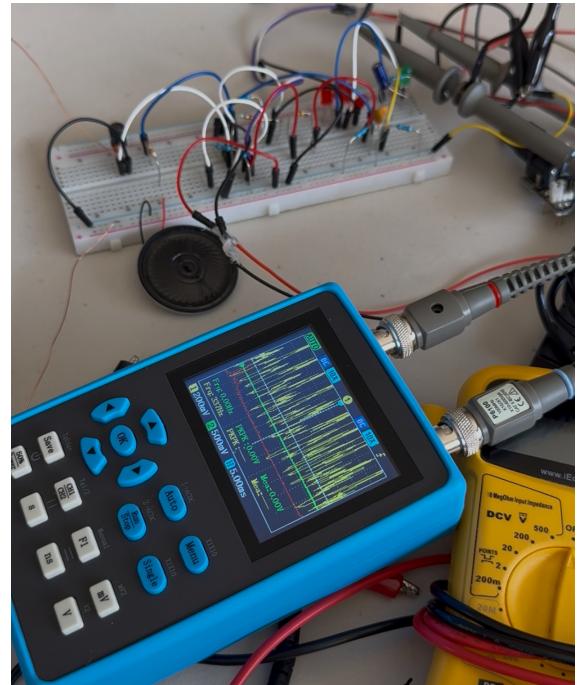
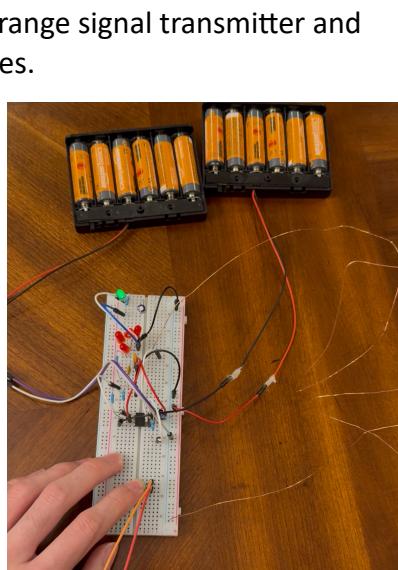
**AM Radio** - An AM radio built from linear components, two op-amps and a few diodes.

A long copper wire (~10 m) serves as the antenna, which is fed into an LC tank circuit. This is amplified twice, in total by a factor of about  $10^6$ , then the envelope is extracted with a low-pass filter and sent to a speaker.



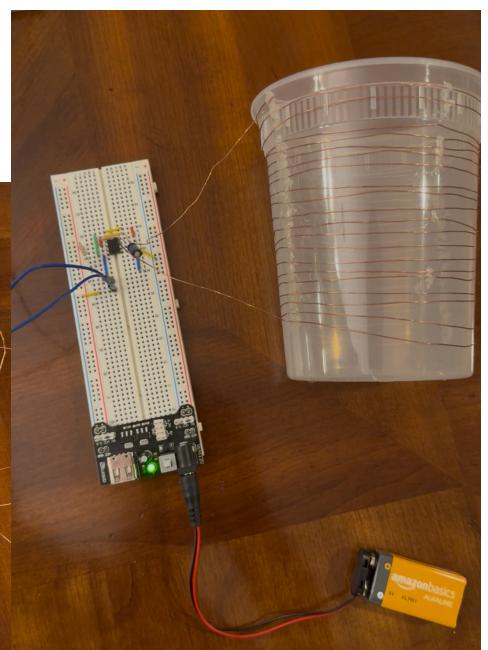
**Wireless Transceiver** - A (very) short-range signal transmitter and receiver using low frequency EM waves.

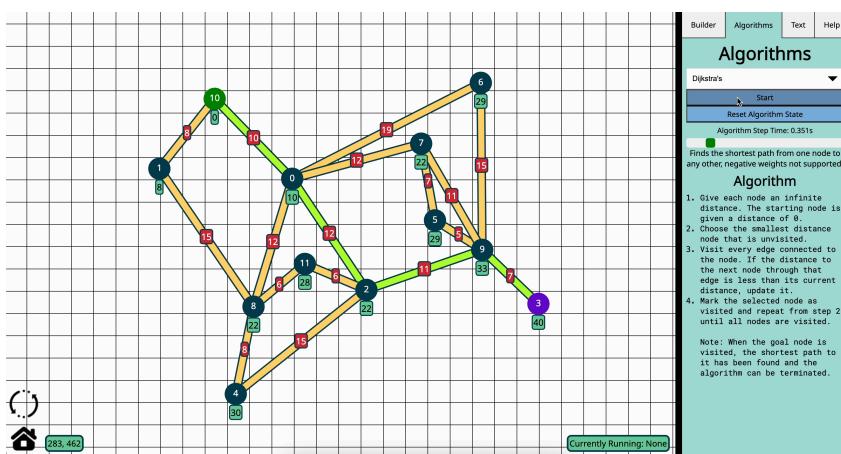
A 555 creates a periodic signal when triggered, which is sent and received by loops of wire, then amplified, rectified and smoothed out to recover the original signal.



**Kelvin Water Dropper** - A device capable of creating a large charge difference through positive feedback on small charge-carrying water droplets.

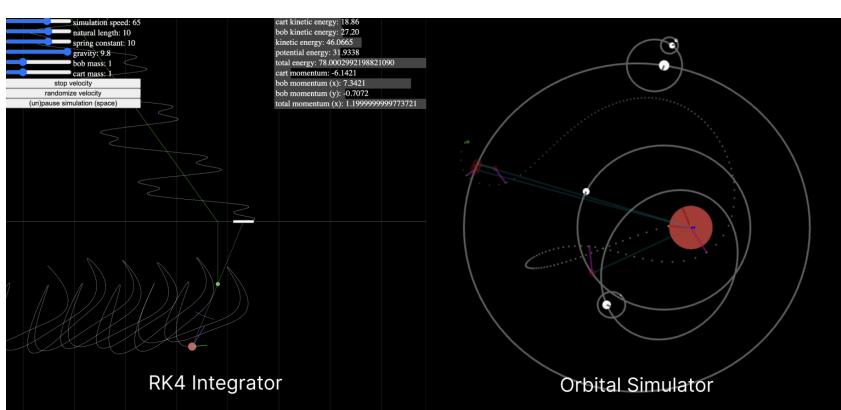
A spontaneous small charge difference in one reservoir pulls charges of the same sign into the falling water droplets because of the crossed wires, creating positive feedback that causes charge to exponentially build until repulsion between water droplets becomes too large.





**Graph Algorithms** - A visualization program for simulating algorithms on custom graphs.

After constructing a graph, the program can visually run through various graph algorithms, including Dijkstra's, Tarjan's, and Prim's, showing which edges are being traversed, values associated with each node, and an explanation of how every algorithm works.

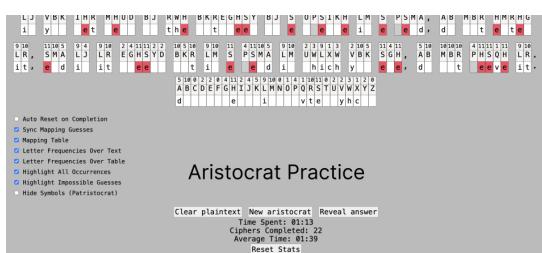


**RK4 Integrator** - A simulation of a spring attached to a cart and a free mass.

Run by integrating the Lagrangian using 4th order Runge-Kutta.

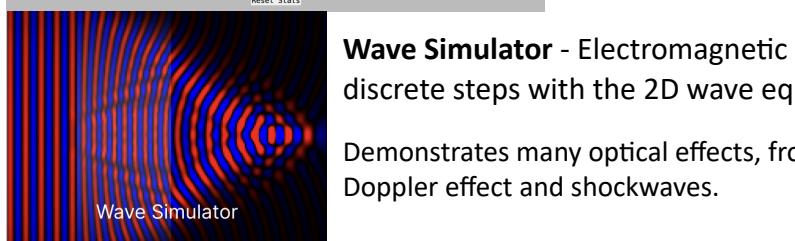
**Orbital Simulator** - Simulation of a small mass flying around a solar system.

The simulation is fully deterministic, and shows the exact path the next launch will take.



**Aristocrat Practice** - Practice for a substitution cipher for Science Olympiad.

Created as a practice resource for our team, I included many customizable options to make the experience more like solving them on paper.



**Wave Simulator** - Electromagnetic wave simulator, run by taking discrete steps with the 2D wave equation.

Demonstrates many optical effects, from refraction and diffraction to the Doppler effect and shockwaves.



**Machine Learning Cars** - Cars learn to drive around a track, powered by reinforcement learning.

**Tutor Pairing** - A program that pairs tutors and students, used by the Study Buddies program at my school.