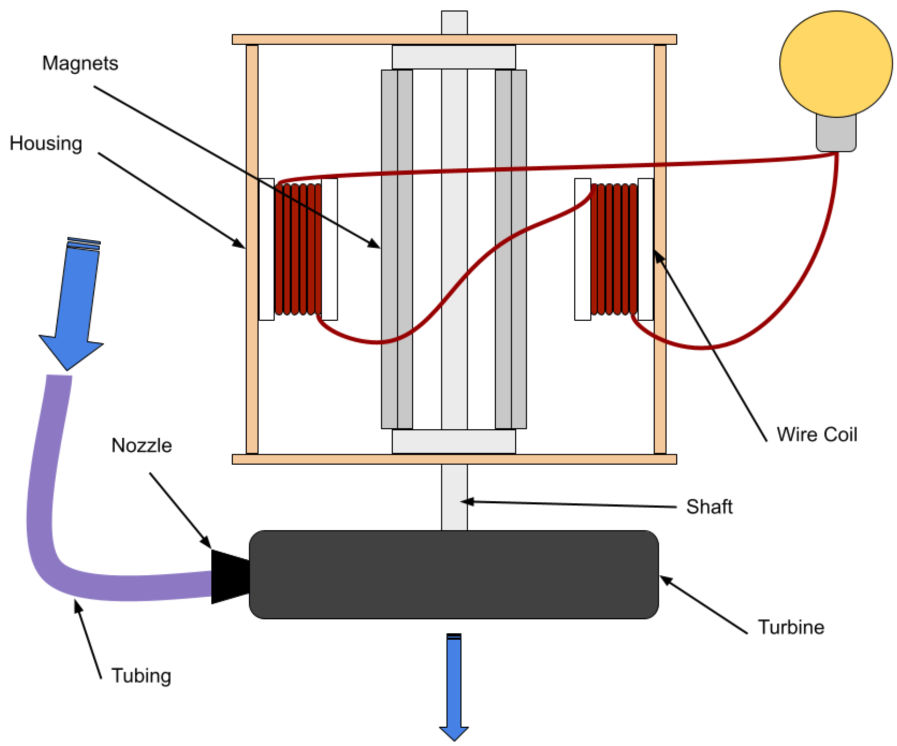
Project D

Team HydroPower



Hydroelectric generator

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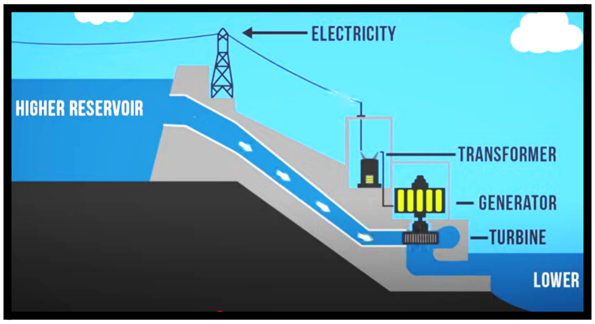
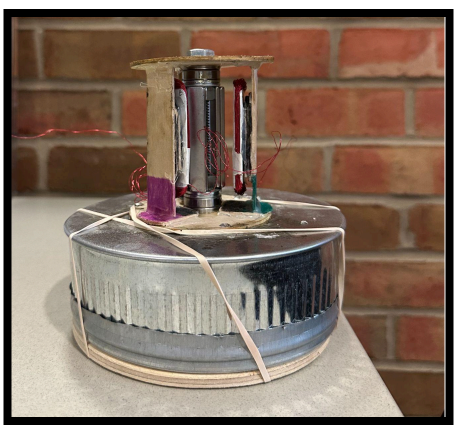
Purpose:

For our project D we decided to make a hydroelectric generator capable of turning on a lightbulb. We took the idea from everyday life: meaning the hydroelectric power plants all over the country that run 24/7 to power our neighborhoods, industries, businesses, and OCC. Each hydroelectric plant is located near a source of running water like a river or dam and uses this natural-occurring force to spin a turbine, causing magnets to pass over coils, therefore generating electricity. We used this in our design in order to better understand Faraday's law and advance our knowledge on one of the most vital technologies to human life.



Our design/procedure:

Our generator consists of a central shaft which rotates inside a stationary housing. Three bar magnets are attached to the shaft, and three coils of copper wire are attached to the housing. This covers two topics in our class: electricity and magnetism. When water from the sink hits the turbine it'll cause it to spin, causing the magnets above it to pass repeatedly over 3 coils of wire. This creates a magnetic field around the coil therefore creating an electric charge. In THEORY, it would power a lightbulb... which we didn't have time to attach to our design. If we wanted to generate more "hydropower," adding more coils of wire or increasing the number of turns on each wire would produce more power according to Faraday's law of induction.



For Faraday's law to apply, there must be a change in the magnetic field. This change can be caused by a moving magnet, a changing electric current in a nearby circuit, or a change in the area of the circuit or the angle between the magnetic field and the circuit.

Calculations:

The generator applies Faraday's Law of Induction in order to generate emf.

$emf = -N_{turns}\frac{\Delta\Phi_B}{\Delta t}$

B is the strength of the magnetic field of a magnet, and A is the area of a coil.

$\Phi_B = B \cdot A \cdot cos\theta$

A proper calculation of the change in magnetic flux would require that we calculate both the change in field strength and field direction as the magnet passes by the coil.

$\Delta\Phi_B = A \cdot \Delta B \cdot cos\Delta\theta$

Since this would be very challenging, the change in flux is approximated instead.

$\Delta\Phi_B \approx (B_{peak} - B_{min})A$

The peak field was found using a teslameter.

$B_{peak} \approx 1mT$

The minimum field was assumed to be 0.

$B_{min} = 0T$

$\Delta\Phi_B \approx 1mT \cdot A$

$A_{coil} \approx 9.75cm$

$N_{turns} = 200$

$emf = -200\frac{9.75\times10^{-5}}{\Delta t}$

All that remains is to calculate the change in time. Delta t is the time it takes for the change in flux to occur. Our design has three equidistantly spaced magnets on the central shaft. Therefore, delta t can be defined in terms of rotations per second as one third of a rotation.

$\Delta t = \frac{1}{3 \cdot rps}$ where $rps \equiv rotations\ per\ second$

The design also has three separate coils of 200 turns, meaning that the total number of turns in consideration is 600.

$$|emf| = 3 \cdot 200 \frac{9.75\times10^{-2}\cdot1\times10^{-3}}{\frac{1}{3\cdot rps}}$$

The generator was tested using a drill that spun at 450 rpm, or 7.5 rps. At this speed, the emf predicted is:

$$\left|emf_{pred}\right| = 3 \cdot 3 \cdot 7.5 \cdot 200 \cdot 9.75 \times 10^{-5} = 1.316V$$

The actual voltage measured was:

$$\left|emf_{exp}\right| = 1.21V$$

This gives a percent-difference of:

$$\frac{1.21-1.316}{1.316} \times 100\% = -8.055\%$$

Sources of Error:

After completing the project, we identified several sources of error. Firstly, resistive losses at coil-to-coil connections create IR drops that lower the terminal EMF and bias measurement lows. Secondly, peak B-field readings are sensitive to probe angle, placement, and timing which add scatter and potential bias to the EMF estimate. Finally assuming the coil's minimum field is zero is unrealistic with closely spaced magnets. This is because a residual field reduces the change in B-field which inflates the predicted eMF relative to measurements.

Go out with a bang:

All in all, this project was filled with valuable insights into the physics behind everyday life. We are incredibly proud of our teamwork to create this hydroelectric generator and are pleased it was a success. This motivates us–a team of physicists–to go on and create more amazing inventions to further understand everyday technologies and the infamous *Faraday's law*.