ELECTRIC MOTOR

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Abstract

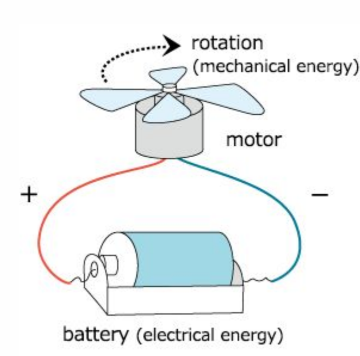
In this project a simple electric motor was built, which basically identifies the relationship between electricity and magnetism, and how the combination of these two allows it to work, and thus be able to pass electrical energy to mechanical energy. We also applied concepts seen in class, such as the moment of Torsion, the laws of electromagnetic induction, and electric and magnetic fields.

Introduction and Methodology

The conversion of energy into an electric motor is due to the interaction between an electric current and a magnetic field. A magnetic field, which is formed between the two opposite poles of a magnet, is a region where a force is exerted on certain metals or other magnetic fields. An electric motor takes advantage of this type of force to spin an axis, thus transforming electrical energy into mechanical motion.**[1]**

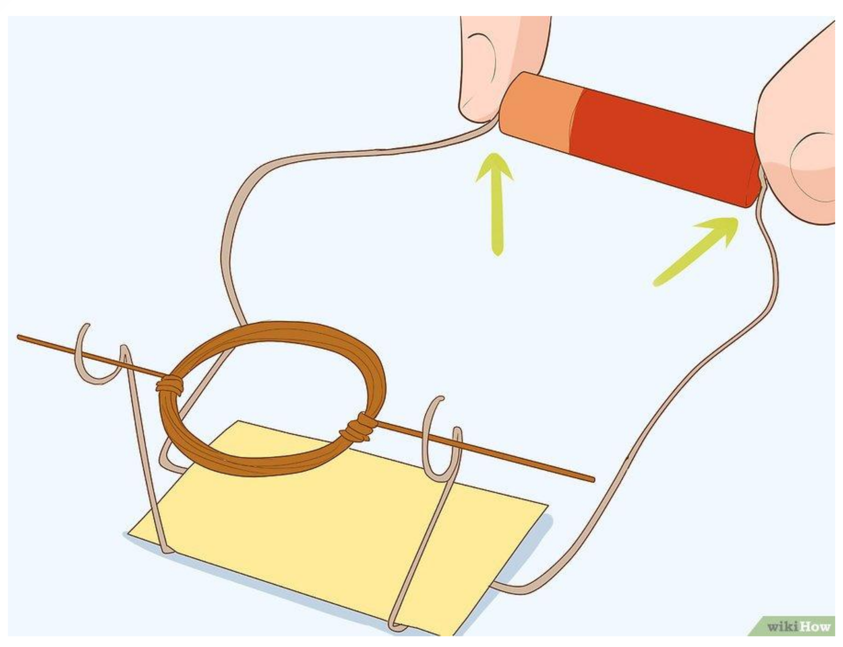
The "Lorentz Force Law", discovered by the Dutch physicist and mathematician Hendrik Antoon Lorentz (1853-1928), postulates that when an electrically charged particle moves within a magnetic field it experiences a force perpendicular to the direction of that movement and perpendicular, in turn, to the direction of the magnetic field flow. Demonstration of how the "Lorentz Law of Force" acts using the "Rule of the left hand".

When the electric current circulates or flows through a conductor cable, a magnetic field is created around it, whose lines of force appear following the same direction of the hands of the clock, or in opposite direction, according to the polarity of the source of electromotive force (FEM) that has connected supplying the electric current. To determine in each case in which direction these lines of force are created, the "Ruler of the right hand" is used.



$$\vec{F} = \underbrace{q\vec{E}}_{\text{Electric force}} + \underbrace{q\vec{v} \times \vec{B}}_{\text{Magnetic force}}$$

$$\overline{F} = I\overline{L} \times \overline{B}$$



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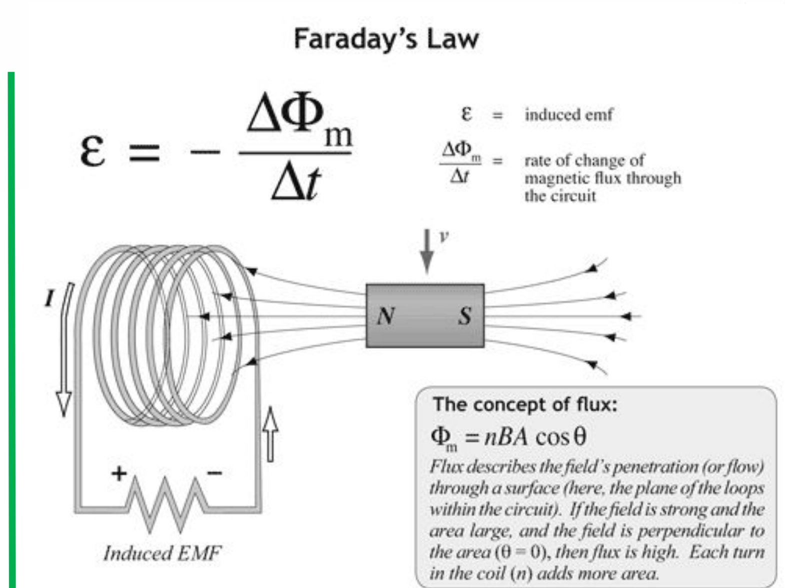
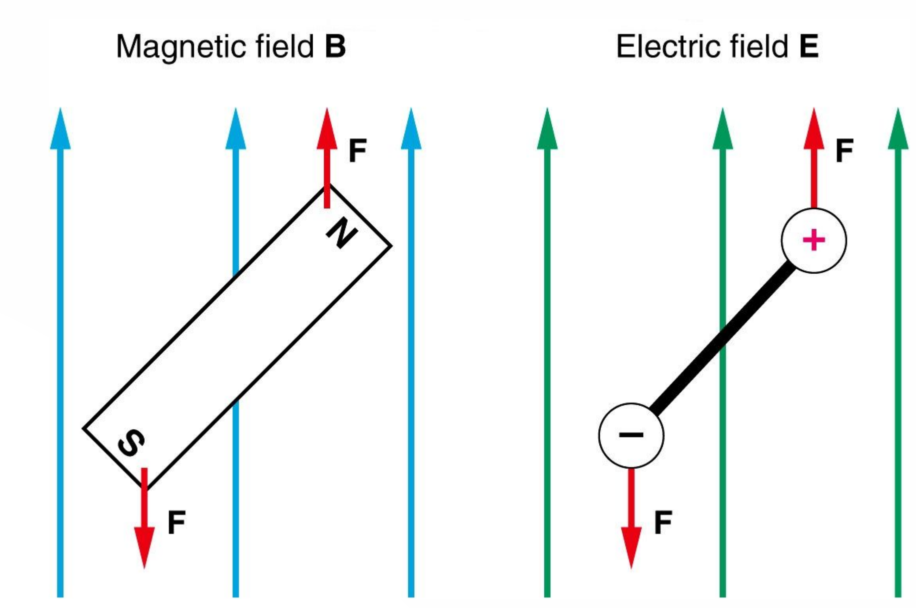
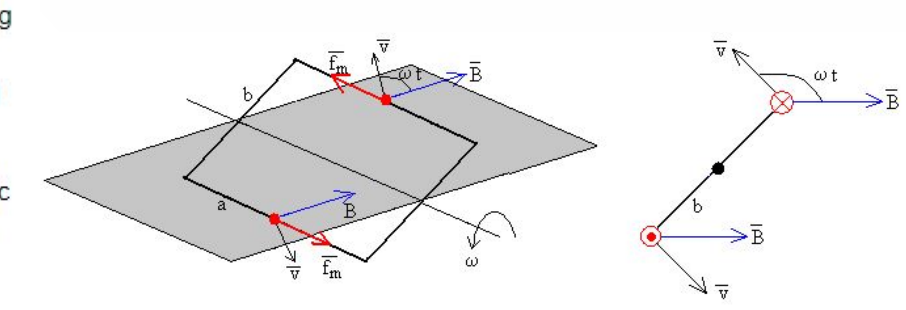
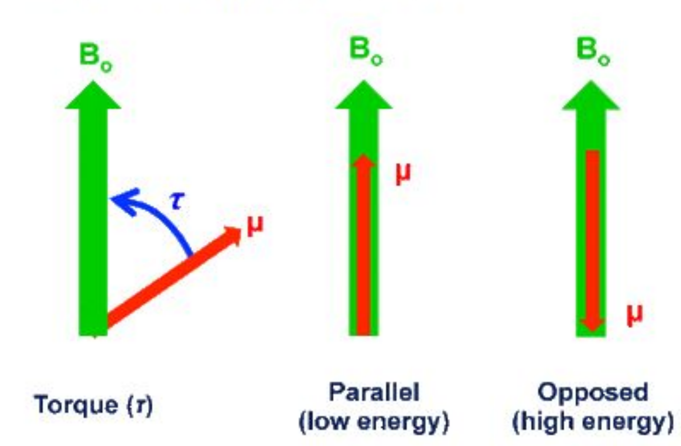




An alternative and more quantitatively useful definition of the magnetic moment is to model it as arising from a tiny current (i) traveling around the edge of a loop of cross sectional area (**A**). The magnetic dipole moment (**μ**) is a vector defined as **μ** = i **A** whose direction is perpendicular to **A** and determined by the right-hand rule.

Like a compass needle, the magnetic moment (**μ**) will seek to align with an externally applied magnetic field (**B₀**). It will experience a ***torque*** (τ) or twisting force given by the vector cross product $\tau = \mu \times B_o$. When perfectly aligned parallel to **B₀**, **μ** will be in its lowest energy state and experience no torque. When pointing opposite to **B₀**, **μ** will be in its highest energy state because extra energy would be required to move and maintain it in this position. For any other direction the energy (E) of the magnetic moment (**μ**) would be given by the vector dot product: $E = -\mu \cdot B_o$. The negative sign is required to account for the energy being lower when **μ** is aligned with **B₀**.





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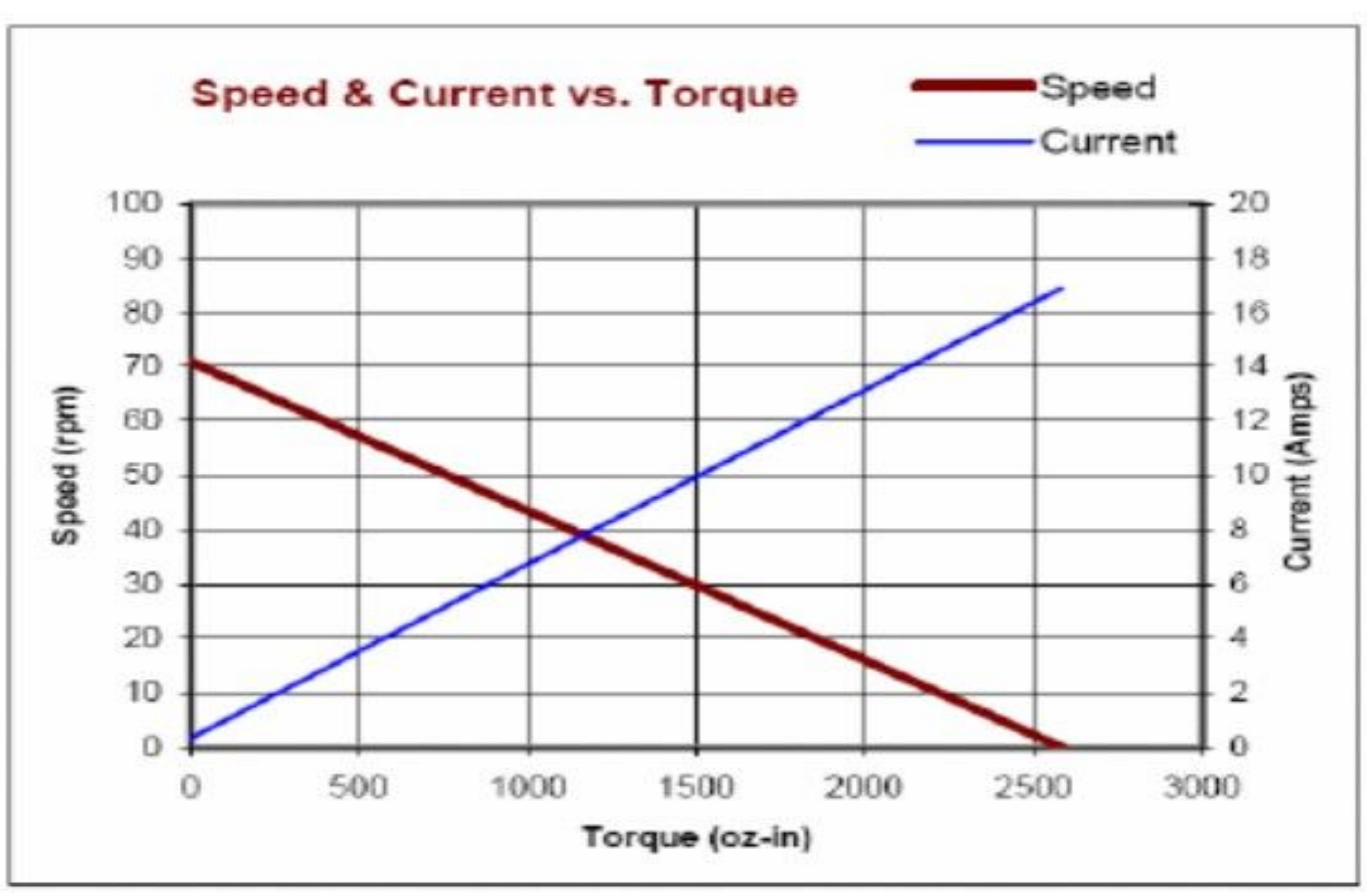
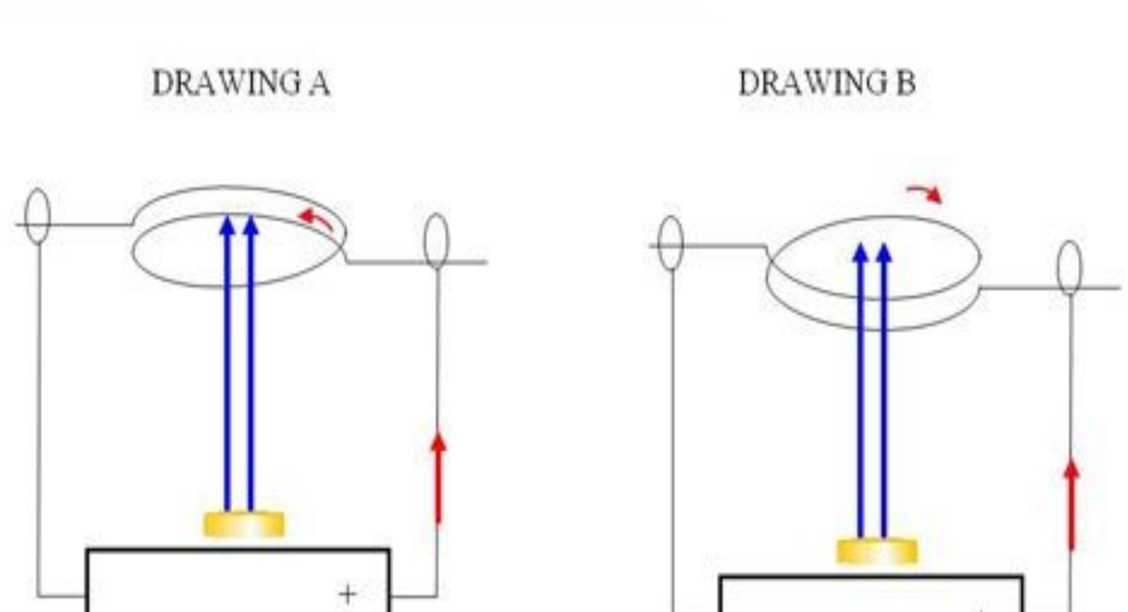
Results and Discussion





Something we have discussed in the past is how varying the voltage to a vibration motor can change the amplitude, particularly with reference to haptic feedback and playing different effects. However, something we haven't explicitly shown is why this happens, or discussed it in the context of a normal DC motor. So in this short article, we will demonstrate how an increased voltage will increase the speed and an increased load will decrease the speed of a motor.

The equation above actually represents a linear motor, in adapting this to an angular rotating motor we consider the flux to be constant at its full value. In doing so it is combined with each constant to produce the torque constant and electrical constant of the motor, denoted kt and ke respectively. As discussed before, these constants actually share the same units, so we can replace both constants in our equation to the value k. Also, we now replace linear speed n with angular velocity ω, so our equation becomes:

$V = TkR + k\omega$

Rearranged for angular velocity:

$\omega = Vk - Tk2R$

In summary, we can highlight the two main variables which affect the speed of the motor in our final equation:

Input Voltage: For a fixed load, the speed of the motor is affected by applied voltage. Increase in voltage = increase in speed

Load Torque: For a fixed voltage, the speed of the motor is inversely affected by the load. Increase in load torque = decrease in speed

The motor speed was fastest when one of three things happened:

1. The armature had more windings
2. The armature was near the center of the ceramic magnet
3. The armature was round vs. square

More windings (loops) made a bigger magnet and bigger magnetic field.
The round armature makes a stronger magnetic field than a square shape making more magnetic force.
Increasing battery power did not seem to increase the motor's speed.

Conclusions

- It was understood in a very practical way phenomena that occur around a current that runs through a conductor.
- A technique was learned to know the direction of rotation of the coil according to the direction of the current, called the law of the right hand, the The thumb is placed in the direction that the bony current flows from the positive terminal to the negative terminal and then the fist is closed and in this direction the coil is going to turn.
- It is very important to know that the number of turns of the wire in the coil influences whether or not there is movement and that the smaller diameter of the coil, the more number of turns is necessary.
- For a fixed load, the motor speed is affected by the applied voltage and for a fixed voltage, the motor speed is inversely affected by the load.

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