Electromagnetism and Generators Experiment Log Book

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Schedule and Timetable:

December 20th, 2023	- Brainstormed ideas for experiment - Started to figure out purpose and experiment type
January 3rd, 2024	- Figured out purpose which is to show how Electromagnetism and Generators work.
January 9th, 2024	- Wrote Hypothesis
January 12th, 2024	- Did research about Electricity to Magnetism and Electromagnets
January 16th, 2024	- Did research on Magnetism
January 22nd, 2024	- Did research on Magnetism to Electricity
January 30th, 2024	- Did research on AC Generators
February 2nd, 2024	- Did research on DC generators
February 8th, 2024	- Did research on Electric Motors
February 12th, 2024	- Did research on DC Motors
February 17th, 2024	- Did research on Conversion Between Motion and Electricity
February 20th, 2024	- Started making project
February 21st, 2024	- Finished making project
February 22nd, 2024	- Wrote our variables for experiment
February 23d, 2024	- Wrote our procedure
February 27th, 2024	- Conducted experiment and wrote observations and recorded video
February 29th, 2024	- Wrote analysis and conclusion
March 6th, 2024	- Wrote our sources of error
March 9th, 2024	- Finished writing all of our citations
March 11th, 2024	- Added the finishing touches to our project

Ideas/Daily Notes:

December 20th, 2023:

- Brainstormed ideas for experiment
- Started to figure out purpose and experiment type

On this day we started our project and we brainstormed ideas about a topic for this project

January 3rd, 2024

- Figured out purpose which is to show how Electromagnetism and Generators work.

On this day we decided our project idea is and started to do some research

January 9th, 2024

- Wrote Hypothesis:

Electromagnetism: If we increase the current/voltage in an electromagnet then its magnetic becomes stronger because as electrons flow through a wire/coil they produce a magnetic field, if we were to increase/decrease the current flowing through a wire, coil, or electromagnet the magnetic field will change in proportion to the current.

For example, if we were to increase the current the magnetic field will grow longer/stronger if we were to decrease the current then it would grow smaller/weaker. This is the relationship between the magnetic field in proportion to the current.

Generator: If we spin the hand crank faster then the voltage on the output will increase because as we spin the hand crank faster it makes the coil spin faster as well, this causes a higher number of electrons to move increasing the current and voltage.

For example, it's similar to increasing the current/voltage in an electromagnet causing the magnetic field to strengthen. If we increase the speed of rotations of the coil in a strong magnetic field then the current/voltage will go up as well. The speed of rotations and the current/voltage are directly proportional to each other.

January 12th, 2024

- Did research about Electricity to Magnetism and Electromagnets

Research:

- First electric generator dates back to a discovery by Hans Christian Oersted and Andre-Marie Ampere in 1820
- Noticed relationship between electricity and magnetism
- Oersted observed → compass needle turned when it was near a wire with a electric current
- Amount of deflection depended on how much electric current flowing in the wire
- When direction of current reversed, needle of compass movies in opposite direction,
- When current interrupted, magnetic effects stopped

References:

- Science Focus 9 By Barry Edgar - Unit 4, Topic 6, Pages 309-317 (textbook)

January 16th, 2024

- Did research on Magnetism

Research:

Electromagnets:

- If soft iron core inserted into coil of wire, and if current passed through wire, a stronger temporary magnet called electromagnet is created
- When electric current flows through coil, one end is the magnetic north pole, other is the south pole
- The more iron coils of wire wrapped around the iron core, the strength of magnet increases
- If current increases, the strength of magnet increases
- If direction of current reversed, polarity of magnet reversed
- If current turned off, iron core loses its magnetic properties
- Strength of electromagnet depends on the core material
- Iron core more effective than other metals, wood, plastic at producing strong electromagnets
- Michael Faraday (1791-1867) → Discovered the basic principles of electromagnetism
- Faraday was interested in chemistry and physics while reading science texts while employed as bookbinder
- At 21, accepted to be laboratory assistant tot Humphrey Davy
- Faraday's experiments form basis of modern electromagnetic tech and electrochemistry
- Introduced term such as → ion, electrode, cathode, anode,
- Invented idea of lines of magnetic force
- "Farad" → unit for stored electricity (named from his name)
- Faraday made contribution to the study of electromagnetism (one of the four fundamentals forces nature)
- Discovered Faraday's law of electrolysis (Math to connect current flowing through a circuit to the mass of chemical substance moving through the battery)
- Discovered/ isolated different compounds (benzene)
- Faraday's law - describes concept of electromagnetic induction
- Electromagnetic = electricity + magnetism → led to development of generators, motors, other circuit technology
- Faraday did all this by trying stuff in his lab
- Faraday disc: Electric generator where electricity is generated by rotating a metal disc through magnetic field
- Faraday cage: Shield against outside electromagnetic fields (covered room in foil , realized that if you have a conductive shell, it will distribute electric charges in a way so that electromagnetic fields are kept outside the shell, and stop it from coming into the shell)
- Faraday cages used to shield sensitive electronics from outside interference
- "Farad" unit of measurement which is used to describe amount of charge stored in system
- An electromagnet is a magnet that uses electricity to power it.
- This type of magnet is that you can turn the magnet on and off
- Magnets are pieces of metal, like iron, that have the ability to attract other metals.
- First, a piece of iron, such as a rod of iron or even a nail, is wrapped in a strand of copper wire.
- Then, using a battery or other device, electricity is run through the copper wire
- This creates a electromagnet
- The electricity running through the wire magnetizes the iron bar, which means that it makes it attract other metals.
- You can shut off the electromagnet by stopping the electric current running through the copper wire and you've just got a chunk of iron with no magnetic properties.
- Two main ways that the strength of an electromagnet can be changed

- One way is to simply increase the amount of electricity running through the wire = make the electric current stronger, hence making the magnet stronger.
- A second way is to wrap the copper wire even tighter around the iron, making less space between the coils and therefore more turns around the iron. = increase the amount of electricity running over the iron and make the magnetic power stronger.
- Toasters use electromagnets to provide heat and to tell the toaster when to pop up the bread.
- Blenders, drills, and even generators use electromagnets to help power the motors.
- Electromagnetic door locks are used to keep doors secure. The doors are kept locked using an electromagnet and a metal plate, until someone pushes a button to stop the electrical current, and then the door can be opened.
- A simple electromagnet consists of an electric power source connected to a wire coiled around a soft iron bar.
- The main advantage of an electromagnet over a permanent magnet is that the magnetic field can be quickly changed by controlling the amount of electric current in the winding. However, unlike a permanent magnet that needs no power, an electromagnet requires a continuous supply of current to maintain the magnetic field.

References:

- Science Focus 9 By Barry Edgar - Unit 4, Topic 6, Pages 309-317 (textbook)
- Sci Show - How Michael Faraday Changed the World with a Magnet | https://www.youtube.com/watch?v=32_3Um3a6_5s (video)
- CrashCourse - Magnetism: Crash Course Physics #32 | https://www.youtube.com/watch?v=s94suB5uLWw (video)
- Research Channel - How Magnets Produce Electricity | https://www.youtube.com/watch?v=6xhqMDMMgz0 (video)
- Study.com - Tammie Mihet - Electromagnets Lesson for Kids: Definition, Facts & Uses | https://study.com/academy/lesson/electromagnets-lesson-for-kids-definition-facts-uses.html (video)

January 22nd, 2024

- Did research on Magnetism and Magnetism to Electricity

Research:

Magnetism

- 19th century: Electric currents can create magnetic fields
- Magnetic fields do induce electric currents, only when magnetic field is changing with time (led to creation of hard drives)
- Faraday's Law of Induction: Constant magnetic field didn't cause an electric current in loop of wire, a changing magnetic field did
- Faraday's Law of Induction: A changing magnetic field will induce and EMF in a loop of wire (EMF - Electromotive force which causes electrons to move and form a current)
- Other things which induce EMF:
    - Changing area of loop of wire
    - Changing angle between loop in magnetic field
    - Magnetic flux induces EMF (Magnetic flux → measure of magnetic field running through loop of wire, when field changed, EMF induced)

Magnetism to Electricity:

- Magnetic effects produced by electric currents
- *Electric currents can also be produced using magnets*
- Michael Faraday and Joseph Henry found this out in 1831 (Worked individually)
- Found → voltage developed in wires which moved at an angle to nearby magnet
- When magnet and wire moved parallel to each other, no voltage developed
- Faraday and Henry connected wire to load (extended their experiment by doing this)
- Because of this, an electric current flowed through circuit, but only as long as either wire of magnet or both were moving
- If wire wrapped into coil around magnet, it increased the current

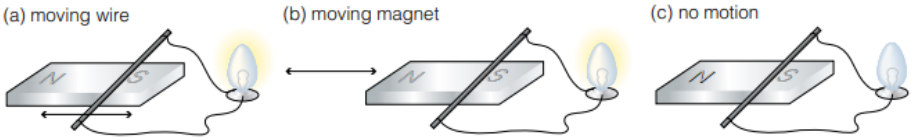


Figure 4.35 Relative motion between a wire and magnet causes a current to flow in a circuit connected to the wire.

- Potential difference (voltage) is applied in a wire when there is motion between wire and nearby magnet
- When wire connected to circuit, "induced current" flows
- This connection between magnetism and electricity was used to develop motors, generators, and other electric tech before scientific theories were developed to explain relationship

References:
Science Focus 9 By Barry Edgar - Unit 4, Topic 6, Pages 309-317 (textbook)
Research Channel - How Magnets Produce Electricity | https://www.youtube.com/watch?v=6xhqMDMMgz0 (video)
Study.com - Tammie Mihet - Electromagnets Lesson for Kids: Definition, Facts & Uses | https://study.com/academy/lesson/electromagnets-lesson-for-kids-definition-facts-uses.html (video)

January 30th, 2024

- Did research on AC Generators

Research:

AC Generators:

- Has a coil of wire which rotates around stationary field magnet
- Coil rotated by external force such as steam, falling water, wind
- Large generators usually use electromagnets rather than permanent magnets
- When wires in coil rotate, electrons move along wire in one direction
- After one-half revolution of wire loop, each side of coil passes near the opposite pole of magnet
- Electrons in the coil start moving in the other direction
- Direction of the current from the generator charges twice with each revolution
- Alternating current → electricity produced by AC generator because it changes direction or alternates

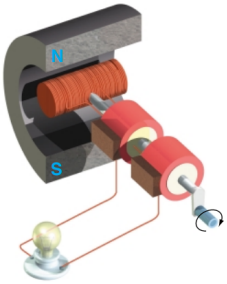


Figure 4.36 In this AC generator, electric current is produced when a coil of wire is rotated inside a magnet. (As you know, current can also be produced when a magnet is rotated within a coil of wire.) In this hand-cranked model, everything attached to the shaft rotates as a unit.

- In North America, generators turn at a controlled speed, provides alternate current which changing direction 120 times per second
- On a graph, current has a wave shape, 60 complete waves per second → 60hz or 60 cycle AC
- Generators produce alternating currents → called generators
- Car electrical systems often use alternator to generate AC
- AC converted to direct current for motor's ignition system

References:

Science Focus 9 By Barry Edgar - Unit 4, Topic 6, Pages 309-317 (textbook)
Study.com - Lori Houston - How Does an Electric Generator Work? |
https://study.com/academy/lesson/electromagnets-lesson-for-kids-definition-facts-uses.html (video)
Study.com - Motor vs. Generator | Mechanism & Energy Conversion |
https://study.com/academy/lesson/electric-motors-generators-converting-between-electrical-and-chemical-energy.html (video)

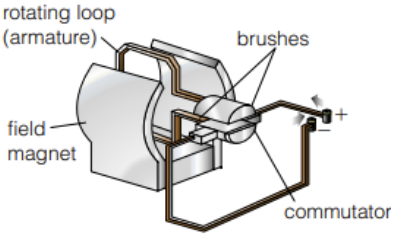
February 2nd, 2024

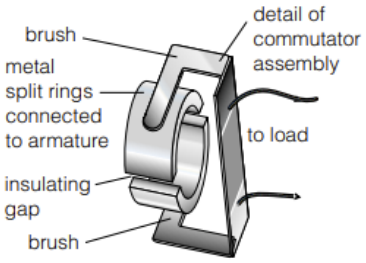
- Did research on DC generators

Research:

DC Generators:

- Generators can also produce direct current (DC), or current in only one direction.
- A generator that produces direct current is often called a dynamo. In a dynamo, the armature, a rotating loop of wire, is connected to the outside circuit by a split-ring commutator.
- Produced current in pulses
- Batteries produce smooth, continuous current
- To visualize how the commutator operates, study the four parts(Refer to image).
- The red dot on the armature lets you track its rotation.)





- In position 1 the brushes touch the metal split rings, so electrons flow from and return to the armature.
- When the armature and commutator rotate to position 2, insulating gaps in the commutator momentarily stop the electric current.
- As the gaps move past the brushes, current resumes (position 3). At this point, the direction of charge flow in the armature has reversed, but so has the connection through the commutator.
- As a result, current continues through the load in a constant direction.
- The same sequence of events repeats continuously as the armature keeps rotating past position 4.

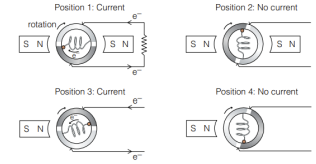


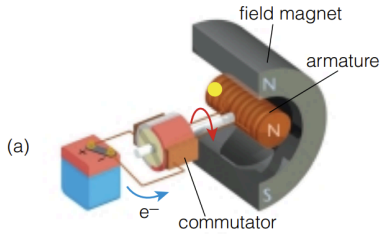
Figure 4.38B These end views of the DC generator in Figure 4.38A show the changing position of the two halves of the commutator. Current through the load is not constant, but it is one-directional.

References:
Study.com - Coralie Nettles - Alternating Current | AC Definition, Advantages & Uses | https://study.com/learn/lesson/alternating-current-advantages-uses.html (video)
Linkedin - Features, Advantages, Disadvantages Of Alternating Current - Md Mukter (Electrical Engineer)| https://www.linkedin.com/pulse/features-advantages-disadvantages-alternating-current-md-mukter-xmnbf (Article) (website)
Sparkfun - Alternating Current (AC) vs. Direct Current (DC) - SHAWN HYMEL https://learn.sparkfun.com/tutorials/alternating-current-ac-vs-direct-current-dc/all

Wikipedia - Electric Generator | https://en.wikipedia.org/wiki/Electric_generator (article) (website)

February 8th, 2024
Research:

- Did research on Electric Motors
- Motor can be constructed exactly the same way as a generator
- Motor uses electric energy to make a coil of wire spin between the poles of a magnet (the "field magnet"), instead of producing electricity.
- Happens because the coil (armature) is connected to a source of electricity energy
- Current flowing through the coil turns it into an electromagnet, which is rotated by magnetic forces from the field magnet.
- **The fundamental law of all magnets — opposite poles attract and like poles repel — is the basis upon which electric motors function**



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DC Motors - DC Motor, How does it works? - Lesics | https://www.youtube.com/watch?v=LAtPHANEfQo (video)

February 12th, 2024

- Did research on DC Motors

Research:

DC Motors:

- Common design for DC motors, a rotating wire coil (an armature) becomes an electromagnet as current flows into it through a split ring commutator.
- The armature is attracted and repelled by stationary field magnets near it, so it begins to rotate.
- The commutator acts as a switch, cutting off and then reversing the direction of current flow to keep the armature turning.

- electrons flow to the right from the battery to the commutator into the armature
- the north pole of the armature is repelled by the top of the field magnet and attracted by the bottom of the field magnet
- the armature begins to rotate clockwise (the yellow dot lets you follow the rotation)

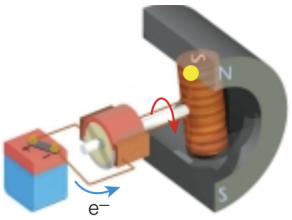
- the commutator cuts off the current so the armature does not stall as it passes close by the field magnets
- the momentum of the spinning armature keeps it moving clockwise

- the commutator reverses the direction of current through the armature
- the ends of the armature reverse their magnetic polarity
- the top of the armature is again repelled by the top of the field magnet and attracted by the bottom of the field magnet
- the force on the armature continues to rotate it clockwise

References:
Science Focus 9 By Barry Edgar - Unit 4, Topic 6, Pages 309-317 (textbook)

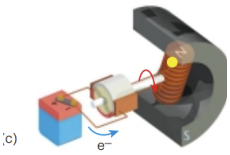
February 17th, 2024

- Did research on Conversion Between Motion and Electricity



Research:

- Electrical generators convert mechanical energies into electrical energies.
    - People convert energy by clapping our hands together. When we clap our hands, we move them toward each other; that motion is mechanical energy. Make a clapping noise; this is sound energy. So by clapping our hands, we convert mechanical energy into sound energy, a simple form of energy conversion.
- To convert mechanical energy into electrical energy, the generator must include several materials.
    - Need some metal wire. While almost all metal wires will work, some work better than others. Copper wire is great because it has a large amount of free electrons, these carry the electricity at a steady flow through the wire.
    - We also need some very strong magnets. We will use that field to move our electrons along the wire.
    - We need force to create mechanical energy, which we will convert into electrical energy.



- Placing our magnets close to each other and letting their magnetic poles attract one another, but not allowing the magnets to pull completely together, we create a strong magnetic field. Now if we take a single piece of copper wire and move it through the magnetic field between the magnets, then this action causes electricity to flow through the copper wire by rapidly moving the wire's electrons.
- The electrons in the wire have their own magnetic fields around each of them, and when they come into contact with the strong magnetic fields of our magnets, they attempt to pull together. But because the strong magnets are stabilized and don't move, the electrons in the copper wire move toward the strong magnets, creating an electron flow(electricity)
- To make electrical energy, the generator needs a magnetic field and a moving wire to come together. The movement of the wire through the magnetic field is mechanical energy. The force of the two coming together makes the electrons start to flow in the copper wire, thus converting the energy into electricity.

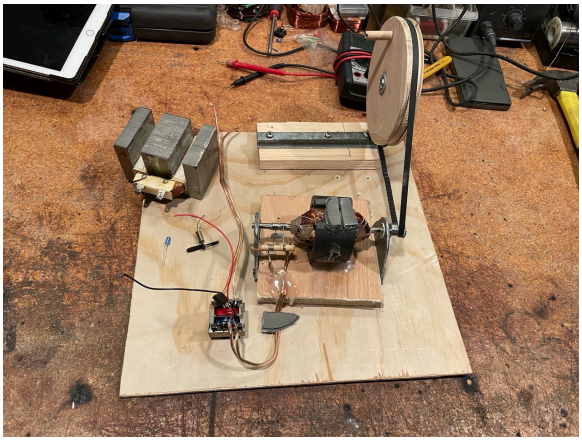
References:
Science Focus 9 By Barry Edgar - Unit 4, Topic 6, Pages 309-317 (textbook)
Study.com - Motor vs. Generator | Mechanism & Energy Conversion |
s:/.com/academy/lesson/electric-motors-generators-converting-between-electrical-and-chemical-energy.html (video)

February 20th, 2024

- On this day we have started to gather materials for our project

February 21st, 2024

- Finished making project



February 22nd, 2024

- Wrote our variables for experiment

Electromagnetism:

Manipulated Variable	**Responding Variable**	**Controlled Variable**
● Current/Voltage Given	● Magnetic Field	● Number of Coils (Resistance of Wires that make up the coil)

Generator:

Manipulated Variable	**Responding Variable**	**Controlled Variable**
● Revolutions Per Minute of hand crank ● Speed of which hand crank is spun and turned	● Voltage/Current in the output	● Number of coils (resistance of wires that make up the coil) and strength of the magnetic field across the coil

February 23rd, 2024

- Wrote our procedure

Electromagnet

1. have a transformer core with only the primary coil intact (thicker coil)
2. attach a power supply of which you can change the output current
3. attach its polarities (+ or -) to either end of the electromagnet
4. gradually increase the current and attach any metal object to it and see how strong it is to take off
5. grab the weight meter/hand held scale and attach it to the hooked metal plate
6. start pulling it until it comes off and record how much weight it took

Materials:

- transformer core with only primary coils attached
- power supply or a source to power the magnet (the power supply must have the ability to change its current)
- metal plate that has a hook
- a hand held scale (pounds and/or kg)

Generator

1. have the generator ready
2. have a multi meter attached to the two terminals of the generator on either AC or DC
3. gradually spin the crank faster and record the data

Materials:

- a multi meter with both AC and DC voltage readings
- bridge rectifier
- transformer to step up the AC voltage
- wires
- hot glue
- cut out ring from extendable antenna (slip ring commutator)
- spring for brushes
- metal rod for axial
- bearings
- two coils of different lengths but almost same amount of turns
- a belt and gear system
- two round magnets
- string to rap around the coils

February 27th, 2024

- Conducted experiment and wrote observations and recorded video

Video: https://youtu.be/va8BQ817pWo?feature=shared

Qualitative:

Magnetism	**Generators**
As I increased the current the amount of strength to take off the plate increased. I experimented with the scale but also numerous metal objects, the same had happened. **While carrying various weights, we noted that the electromagnet's magnetic field strength varied depending on the amount of current passing through it.** **By manipulating the voltage while keeping the current constant, we observed changes in the electromagnet's magnetic field strength. Higher voltages consistently led to stronger magnetic fields, demonstrating the direct relationship between voltage and magnetic intensity.** **After testing I had touched the coil and it had felt warm.**	**As I spun the crank faster and faster the voltage began to increase. We managed to get about 25 volts by using our step up transformer.** **When powering light bulbs and various loads, we noticed that the generator produced different levels of electrical output depending on the speed we spun it at.** **Increasing the rotational speed of the generator's coil resulted in a proportional increase in both current and voltage outputs.** **We noticed that the lightbulb flickers when we used AC current and when we use DC Current the lightbulb didn't flicker.** **The fan only worked on DC current**

February 29th, 2024

- Wrote analysis and conclusion

After Conducting our experiment we got the results:

<u>Electromagnetism:</u>

We got these results because

The force to remove an object from an electromagnet increases as you increase the current flowing through it due to the fundamental relationship between current and magnetic field strength.

When an electric current flows through a wire, it creates a magnetic field around the wire according to Ampère's law. This magnetic field interacts with any nearby magnetic materials, such as ferromagnetic objects like iron, creating a force on them.

The strength of this magnetic field, and consequently the force it exerts on nearby objects, is directly proportional to the current flowing through the wire.

So, when you increase the current flowing through the electromagnet, you increase the strength of the magnetic field it produces. As a result, the force exerted on any nearby magnetic objects, such as the object being held by the electromagnet, also increases.

We got these results because...

In a generator, the generation of voltage is governed by Faraday's law of electromagnetic induction. This law states that a changing magnetic field induces an electromotive force (EMF) in a conductor. When you spin the generator faster, you are effectively increasing the rate at which the magnetic field passing through the coils of wire changes. This increased rate of change of the magnetic field induces a higher voltage across the terminals of the generator.

When you spin the generator faster, you're essentially causing the coil to cut through the magnetic field more rapidly. This results in a faster rate of change of the magnetic flux through the coil, which in turn induces a higher voltage. Mathematically, the induced voltage (EMF) is directly proportional to the rate of change of the magnetic flux, which is directly related to the rotational speed of the generator.

Conclusion:
In conclusion, our experiments aimed to show the workings of electromagnetism and generators, and we're happy to say that our hypotheses have been confirmed through our investigations. By experimenting with the manipulation of current and voltage in electromagnets, we've discovered a direct relationship between these variables and the strength of the resulting magnetic fields. Essentially, increasing the flow of electricity through an electromagnet leads to a directly proportional increase in the intensity of its magnetic field, while reducing the current or voltage weakens magnetic strength. This finding not only confirms fundamental principles of electromagnetism but also shows us the practical applications of this in various technologies, from MRI machines to electric motors.

Similarly, our experiment into generators had results consistent with our hypotheses. By increasing the rotational speed of the generator's coil, we observed a corresponding rise in both current and voltage output. This direct correlation between rotational speed and electrical output emphasizes the significant role of generators in converting mechanical energy into electrical energy. Moreover, it highlights the scalability of this relationship, demonstrating how adjustments in rotational speed can be changed to meet different power demands in real-world applications.

Our project isn't just about experiments, it's about showing how science can be hands-on and practical. By confirming our ideas through experimentation, we've expanded our understanding of electromagnetism and generators. By sharing what we've learned, we're helping others see the amazing ways science impacts our lives and how we can use this in real world applications.

March 6th, 2024

- Wrote our sources of error

Magnetism:

1. Power Supply Variations: Fluctuations in the power supply can affect the strength of the magnetic field produced by the electromagnet. Variations in voltage or current can lead to inconsistencies in the experimental results.
2. Calibration Issues: Inaccuracies in the calibration of measuring instruments such as ammeters and voltmeters can lead to incorrect readings of current, voltage, or magnetic field strength.

3. Temperature Effects: Changes in temperature can affect the resistance of the wire in the electromagnet, leading to variations in the current flowing through it. Temperature changes can influence the magnetic properties of the materials used in the experiment.
4. Alignment and Positioning: Incorrect positioning or alignment of components of the experiment such as the electromagnet, magnetic field sensor, or the object being tested can lead to inaccurate measurements of magnetic field strength or interactions.
5. Friction and Mechanical Errors: In experiments involving moving parts or adjustments, friction or mechanical errors can introduce inconsistencies in the results. For example, in experiments involving the movement of magnets or electromagnets, friction can affect the force exerted.
6. Magnetic Material Properties: Variations in the properties of magnetic materials used in the experiment can affect the result of the electromagnet and the objects being tested.
7. Human Error: Errors in measurement reading, recording, or experimental setup can occur due to human factors such as misinterpretation of readings, improper handling of equipment, or procedural mistakes.

March 9th, 2024

- Finished writing all of our citations

Basic Electronics Course By Norman H. Crowhurst (book)

Britannica - Electromagnetism | https://www.britannica.com/science/electromagnetism (website)

Circuit Basics | https://www.circuitbasics.com/what-is-electromagnetism/ (website)

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March 11th, 2024

- Added the finishing touches to out project and added everything to the CYSF platform

March 15th, 2024

- Project is handed in on platform and started to work on trifold for project