?NYSEd Regent?

An Operative Model for Teaching Sun-Earth Interactions through a study in Magnetism and Electromagnetism

Magnetic

what grade level + setting?

by

Gwen Saylor

C.f. other published P690 projects w/regents curriculum — Say Nick Childs PA4690

A project submitted in partial fulfillment of the requirements of the degree of

Also check format — Kathleen Walker 690 James Kenicutt 690

Required of Use of Appendices.

Master's in Education

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Page #

Abstract

N45SD3

This project seeks to demonstrate an interdisciplinary approach to Earth Science and Physics standards through a case study of the Earth's magnetosphere and solar interactions. Teacher background and sample investigative activities are provided to relate concepts of magnetism and electromagnetism in the context of Sun-Earth interactions. Students will explore concepts in a laboratory setting, through reading articles and through online resources in order to infer the connection between a series of scientific discoveries related to the structure of the Earth and Sun. The student activities focus on an operative model of answering the questions related to Earth-Sun interactions from the perspective of "How do we know?" rather than the facts or "What do we know?"

Use place? Inspired by?

cite definition from source (Anderson)

APA (Anderson, 1989) P—

Introduction:

+ Background

Investigations of large scale phenomena provide an opportunity to foster operative knowledge rather than declarative knowledge. Operative knowledge requires an understanding of the evidence that leads to factual or declarative knowledge [Anderson (1980)]. Lessons that engage students in experiential learning coupled with opportunities for deductive and inductive reasoning lead to operative knowledge [Aarons (1997)]. The activities and sequencing of experiences selected for this investigation are designed to promote an operative knowledge Sun-Earth interaction through a thematic focus on magnetism and electromagnetic induction.

(Arons, 1997, p—)

grade

Use of cites include pg#

Without an operative knowledge students often struggle to master content due to a lack of explanation and inherent doubt. At the conclusion of a lesson based on declarative knowledge students often ask "How do we really know that?" Learning designed around the operative knowledge eliminates ~~the~~ doubt from the outset by engaging students in the explanation.

(is Arons' phraseology)

? operational defn?

If you survey students about prior knowledge of magnetism at the outset of a unit of study you will likely hear responses related to the fact that magnets have two poles, opposites poles attract and like poles repel. The typical student has a very basic understanding of magnetism that reflects having hands on experiences with magnets as a child but little formal learning about magnetism in an investigative setting. Upon questioning, students can provide factual knowledge about the Earth's magnetic field but they are not able provide an adequate explanation for the Earth's magnetic field or explain the origin of magnetism in piece of iron.

OK

Magnets are more than handy tools for hanging exemplary grades on the refrigerator. Magnets are used in numerous devices in our daily lives. Magnetism has implications on the structure of the universe from the smallest to largest scale objects. The structure of the universe and the topic of magnetism are both sources of curiosity for students. This paper and related student activities will focus on the intersection between these topics while drawing upon other areas of prior learning.

The Earth's magnetic field and the Sun's magnetic nature have implications for our space environment. Solar storms can influence satellite technology as well as current carrying devices on Earth. Using the Sun-Earth dynamic as a context for studying the nature of magnetism,

Page#

~~magnetic~~ geomagnetic - cite some refs here please

electromagnetic induction and ~~the~~ dynamo effect will help students understand the many ways in which concepts can be applied to real life issues.

Scientific literacy is a central objective at all levels of science education. True scientific literacy requires that a student recognize the nature of the scientific process as series of concepts and theories that are refined and clarified by further research and testable ideas over a period of time that spans, years, decades or centuries (Arons, 1997). Our knowledge of the Earth's magnetic field has arisen out of the ~~a~~ mutual curiosity of visionary minds including astronomers, geologists, mathematicians, physicists and cartographers. Centuries of inquiry, observation and debate have formed our current geomagnetic model. Modern explorations of the Solar System are delving deeply into the question of magnetism throughout the universe, contributing to our evolving representation of this ever present force. With magnetism as a lens, students ~~will~~ can connect multiple themes of astronomy and earth science to gain knowledge of the universe and the nature of scientific inquiry. By connecting multiple themes students will not only learn about the magnetism but also how we have come to "know" facts about the universe and what questions we are still actively trying to answer.

restate

cite some

planetary

restate

cite some please

The integrated approach described within this document addresses multiple science and technology standards with the NYS Core Curriculum. This document is divided into two sections: Teacher Resources and a correlated Student Activity Journal. All student activities are geared toward the difficulty level of an introductory New York State Regents level course.

Cite more refs on magnetism

TEACHER RESOURCES:

There

Teacher resources are broken down into main sections:

1. History of scientific discoveries
2. Student activities – teacher overview
   Stage 1 activities involve developing a model of the magnetic fields of the Earth and the Sun.
   Stage 2 activities involve understanding the processes that create the magnetic field.

Where?

Guiding students through a series of discoveries reflective of the process of discovery engages them in the process of deductive and inductive reasoning that leads to true understanding of the concept, as well as, develops an appreciation for the process of scientific inquiry. Our current understanding of the Earth's magnetic field results from a series of investigations ~~that~~ spanned across many centuries, continents and career paths. Teachers should familiarize themselves with the history of magnetic field discoveries in order to facilitate student discussion of the discovery process. The historical timeline represents the factual or declarative knowledge that students will gain through the series of hands-on activities.

Cite

details

You can cite a meta-reference that then cites these below (cited in

Ok

HISTORY OF SCIENTIFIC DISCOVERIES

Magnetism has been intriguing humans for thousands of years. Archeological findings suggest that early civilizations of the Mayans, Romans, Greeks, Egyptians and Shang Dynasty were aware of the magnetism in rocks and perhaps the Earth itself [Zirker (2009)]. Chinese merchants are the first known to have used compasses to navigate in 1000AD. The use of the devices spread quickly. Curiosity surrounding observations from early users were noted in navigation journals. Compasses pointed a few degrees off from other navigation tools such as the stars and fluctuated in certain regions of the Earth. These questions lead to the initial scientific speculation into the nature of the Earth's magnetic field.

also see 400 yr centenary websites

Still available from Dover in translation

William Gilbert was the first to conclude through scientific experimentation that the Earth itself was a giant magnet in his book *De Magnete* in the year 1600. Subsequent discoveries of variations in the magnetic declination of London over a single decade intrigued the scientific world. The resulting questions drew the attention of scientists such as Edmund Halley, Alexander von Humboldt and Carl Friedrich Gauss over the next two centuries. Edmund Halley also recorded a brilliant aurora on March 6, 1716 visible in London that clearly showed how the rays of light lined up with the magnetic field. cite

Gauss set up a network of magnetic observation stations throughout Europe to collect more information; ultimately leading to a project known as the Magnetic Crusade which established observatories throughout the British Empire. This project ultimately discovered that the Earth's magnetic fluctuations aligned with the variations in sun spots being studied by astronomers of the day. cite

cite

cite

WAY too much uncited background

In the 1830s, Faraday discovered that moving a bar magnet through a loop produced a measureable electric current in the loop. The reverse was also true. From this discovery, Faraday created a device known as a dynamo which consisted of a copper disk that rotated in the field of a permanent magnet by force of a hand crank. The speed at which the crank was turned was related to the strength of the resulting current. A secondary magnetic field resulted from the electric field. Mechanical energy was converted into both electrical and magnetic energy.

Early in the 20th century, geologists studying lava flows discovered that the embedded magnetic fields in old lava were oriented in the opposite direction to the present magnetic field. Further evidence for repeated magnetic reversals was unveiled with the investigations of rocks resulting from sea-floor spreading on at the mid Atlantic Ridge. Evidence suggests that over the last 10 million years the magnetic poles have reversed on average, every 250,000 years; however, the last reversal is estimated to have occurred around 780,000 years ago. Direct observations of Earth magnetic field, past and present, taken together with celestial events opened of scientific lines of inquiry that intersected with laboratory investigations by Michael Faraday. cite

cite

In 1919, Sir Joseph Larmor connected the idea of Faraday's dynamo to the cosmic magnetic fields. Larmor proposed that temperature variations within the Sun cause electrically conductive gases to move horizontally into vertically moving sunspot fields. An induced current within sun spots was theorized to be the source of the magnetic field around sunspots. Larmor showed how the

P#

dynamo on the sun could be self-generating in that the current induces the magnetic field. He theorized that the same process could be occurring within the Earth's core. Initially the idea was discounted because laboratory results could not replicate the dynamo using the symmetric rotation of the Earth about its axis.

Once the geophysicists learned more about the Earth's interior, the self-sustaining geo magnetic dynamo became the leading theory to explain the Earth's magnetic field and all its "quirks". Newton had already determined that the Earth had a high density core based on his calculations of gravity. gravitational field strength @ the Earth's surface Geophysicists studying seismological data of waves produced by Earthquakes were able to compare and contrast the P and S waves to determine the layers of the Earth.

more & better ties to geomagnetic dynamo? online simulations.

In 1950, Sir Edward Bullard suggested that the convection within the Earth's core could result in electrically conductive materials moving relative to a toroidal field that would explain the Earth's magnetic character. Eugene Parker built upon this work by suggesting that the motion of the fluid in the core would be similar to the action of a cyclone in the atmosphere. A cyclonic convection model together with turbulence in viscous fluid explains the geo magnetic dynamo effect in both the Earth and the Sun. Using some of the fastest computers in the world, Gary Glatzmaier and colleagues were able to reproduce a computerized version of events such as a magnetic reversal and field fluctuations. In 2006, Cary Forest, University of Wisconsin was able to successfully replicate a small scale dynamo resulting in a dipole field within a spherical shape using turbulent movement in a viscous solution of liquid sodium.

Cite

I have read this

Sun's Magnetic Field

Magnetism is not unique to the Earth. The surface of the Sun owes its violent and tumultuous nature to magnetism. Scientists studied the surface of the Sun for years before they knew of magnetisms influence. Observations of sunspots date back to around 1630. Galileo Galilei and Christoph Scheiner each claim to have first discovered sunspots. Over the years many observations of sunspots were cataloged. An eleven year sunspot cycle was reported in 1843, by Heinrich Schwabe, after nearly two decades of research. Richard Carrington later reported that sunspots follow a pattern of emergence that moves toward the Sun's equator as the sunspot cycle progresses.

cite. GG's Logs are online

In 1908, George Ellery Hale hypothesized that magnetism played a part in sunspots when trying to explain whorls observed in a photograph of a sunspot taken at the Wilson observatory. Hale applied a discovery made by Pieter Zeeman in 1896 that showed how magnetic fields alter the spectrum of a gas by creating separations in the lines correlated with the strength of the field. While these line separations did not explain the whorls they did verify the existence of strong magnetic fields in sunspots. Hale's further research led to the realization that sunspots exist in pairs with opposite polarity along an east-west line.

cite
cite
cite

By 1955, Parker linked the differential rotation of the sun observed centuries before by Christoph Scheiner was to the dynamo effect postulated for the Earth to provide an explanation for the existence of sunspots. Parker

abrupt line end?

RH

Tons of background maybe abbreviate into an appendix

Solar Storms and the Aurora

agreement ?

phenomena

Auroras have always been a spectacular ~~way of getting people's attention~~. Generally they are only visible in the night sky over very northern and southern latitudes; however, over the centuries sporadic auroras appeared in populated regions of the globe causing both panic and awe. Several extraordinary events were observed by scientists who made immediate connections to the other areas of inquiry.

unclear restate

In the fall of 1859 a solar researcher noted two extraordinarily bright patches appear on the sun near a large group of sun spots. According to records, the spots brightened, spread out and faded within a matter of minutes. Within 18 hours of this solar observation, telegraph wires across the United States and Europe shorted out, some sparking fires. Simultaneous to these events, a massive aurora occurred across the Northern Hemisphere. In Europe displays were seen as far south as Rome. People in Cuba and Hawaii also witnessed this extraordinary event. Correlations between the events and the magnetic records from the Kew Observatory created the first inkling that events on the sun could be linked to events on Earth. A singular event was not considered conclusive at the time but it did lay the ground work for further inquiry. The connections between these events set the stage for rapid progress.

The effect of the terrestrial magnetic storm on telegraph lines was a source of intrigue in its own right. It was noted throughout the early days of telegraphs that auroras interfered with the functioning of telegraph lines. Following are accounts from telegraph operators working during the September 2nd storm in 1859 that appeared in the 1860 American Journal of Science ??

Telegraph Superintendent.

long quotes are generally a sign of weak writing

> "During the forenoon of September 2d, an unusual current of varying intensity was present most of the time on the wires of the Vermont and Boston telegraph. The polarity of this current appeared to change frequently, sometimes being opposite to, and nearly or quite neutralizing the battery current when an attempt was made to use the line; at other times much increasing the force of the battery current. The auroral current produced the same marks on our chemical paper (we use the Bains or chemical system of telegraph) as those produced by the use of the battery. Signals and messages were transmitted between Boston and Manchester by the sole use of the auroral current."

Cool & worthwhile Quote

(P ——) (cite)

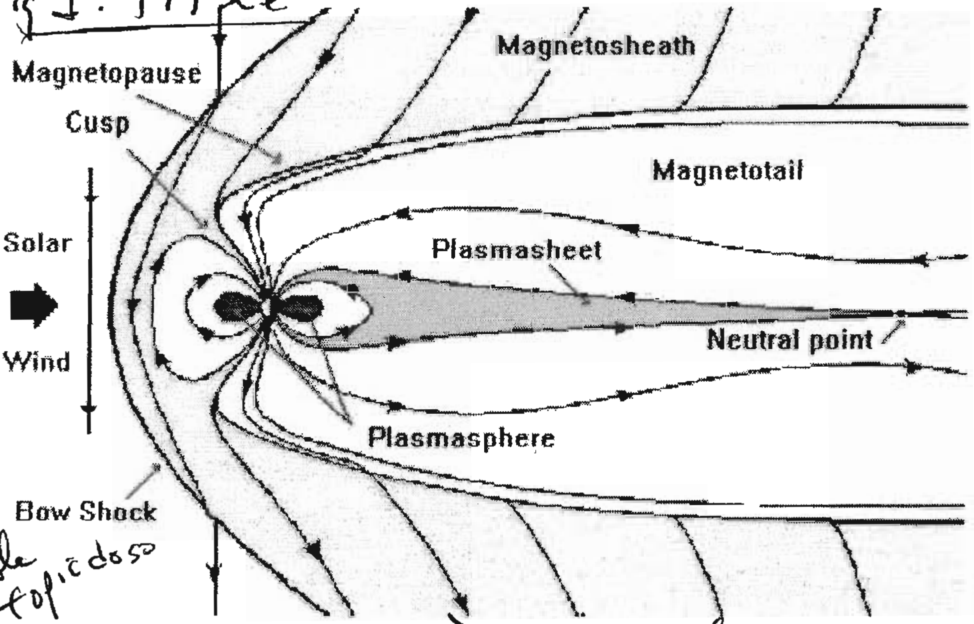
Major progress on the source of auroral currents weren't realized until 1904 when Walter Maunder showed that sunspots located near the equatorial regions of the sun cause the greatest magnitude storms. He theorized that the area around the sunspot emits a stream of some sort that sprays the (cite) Earth. The composition of the stream was theorized by Norwegian physicist, Kristian Birkeland, to be a stream of electrical particles. He experimental showed the ability to create light in a magnetized sphere using charged particles in 1905. Only fifty years after his death were these ideas accepted when satellites confirmed his ideas on auroral currents.

In 1931, the first theory regarding the interaction of the sun's particles and the Earth's magnetic field cite was proposed by Sydney Chapman. He proposed that magnetic storms occurred when the stream of particles hit the Earth's dipole magnetic field it induced electrical currents which in turn induced a secondary field that would compress the Earth's field. This theory explained the sharp increase in the strength of the field at the onset of a magnetic storm. An additional component of his theory was the idea that the stream engulfed the entire region of the Earth's field, creating a cavity on the far side. This was a major step, but failed to fully explain the complex observations of auroras.

Through the 1940's and 1950's a vision of the solar wind interacting with the Earth's magnetic field began to take form. The Earth's magnetic field blocks the particle streams flow and creates an obstruction like an object such as a boat or an animal moving upstream. With the advent of the satellite age, the mapping of the magnetosphere has verified many of the complex predictions relating to the interaction of the solar wind with the magnetosphere. This breakthrough has allowed us to determine the origin of the auroral displays. ?

Cite some? Space weather websites

Fig 1: Title



Where did this fig come from

doesn't the whole topic do so

after <URL> email + request permission if fig is not in the public domain

cite

The magnetosphere and the aurora results from a complex set of interactions that go beyond the scope of a Regents physics course. A simplified version of this phenomenon follows. Aurora's occur as a result of coronal mass ejections (CME's) from the sun as a result of solar storms. A CME is composed of ionized gas particles that leave the surface of the sun do to an explosion of energy. They travel through space as the solar wind. When the ionized particles reach the atmosphere of the Earth and our magnetic field they interact to produce electrical energy and a secondary magnetic field. When the magnetic polarity of the solar wind matches polarity with the daytime side of the Earth, an invisible valve opens in the magnetotail region. This valve allows particles and energy to penetrate deep into the magnetosphere and interact at high altitude with the Earth's atmosphere where the density of air is very low. It is estimated that 900 billion watts of energy are generated as heat with a small percentage as light. The different colors of the aurora result from the ionization of different types of gas molecules.

serious discussion of NYSED Regents scope somewhere please

Earth Sci → Physics

Simplified Discovery Timeline.

2000BCE-
1500AD

Populations all over the world recognize magnetism.
Compasses are first used for navigation.
Initial questions about nature of magnetic field arise

1600's &
1700's

1608 – DeMagnete by Sir William Gilbert is published with the finding that the Earth itself is a magnet.
1635 – Henry Gellibrand discovers the declination of London has changed over a period of 12 years.
1698- Edmund Halley begins magnetic survey of Atlantic Ocean. Resulting map was used throughout the 1700's
1716 – Edmund Halley witnesses an Aurora in London and recognizes magnetic field lines in the light

1800's

1830-1890
Magnetic observatories are set up in Europe and then throughout the British Empire. 11 year cycle in magnetic field intensity is observed
1831-The magnetic north pole is located

1820-Oersted discovers a current in wire generates and electric field
1830's-Faraday demonstrates the dynamo in which a moving magnetic field creates a current in a wire.
1859-An aurora visible of far south as Texas is observed. Some telegraph wires are destroyed while others are observed to function without battery power.

1900's

1904-Magnetic north is observed to have moved 30 km since 1831.
1906-Evidence of magnetic reversals found in rocks.
1926-World-wide magnetic reversals reported based on rock record. Average intervals of 250,000 years between reversals discovered. Timeline of 760,000 years since last reversal determined
1959 –Sea floor spreading further reinforces evidence of magnetic reversals.
1960's to present – Satellites mapping the field continue to show decrease in intensity
2000's-Computer simulations successfully model the Earth's field

1919-Larmor links sunspots currents on the surface of the sun.
1946-Walter Elsasser, using knowledge of the Earth's interior gained from seismic wave data, proposed that flowing material within the core caused the magnetism.
1955- Parker showed how cyclonic currents in the Earth could account for the characteristics of the field.

NYSED stds? by stage & Activity?

STUDENT ACTIVITIES – TEACHER OVERVIEW

STAGE ONE – Magnetic Fields of the Earth and Sun

What are the characteristics of the magnetic fields of the Earth and the Sun?

Magnetism is an invisible force that is difficult for students to visualize. In this phase of the lesson students will explore magnetic fields in a hands-on way in order to understand the conventions used for representing field lines. Guided investigations of NASA web resources will expand the concept of basic field lines to representations of the Earth's magnetosphere and the Sun's heliosphere. Students will be introduced to the major questions driving current research and the types of investigations currently underway within the scientific community. At the conclusion of this phase students will have a foundational knowledge upon which to explore more complex details of Sun-Earth interactions.

Time appreciation for each stage/activity

Activity A: Observing field lines with iron filings

Overview: Students view magnetic field by using iron filings for various arrangements of magnetic poles.

Objectives:

1. Students will be able to characterize interactions between magnets as attractive or repulsive.
2. Students will understand that field lines show the interaction between magnets

Materials:

For each student group – pair of labeled bar magnets, iron filings in salt shaker, small compass, plastic bag

Procedure:

Using a single magnet and a small compass to determine how the north pole of a compass behaves as it is moved around the magnet. Determine the distance at which the bar magnet and compass are able to act on one another.

Continue experiment with a pair of magnets and observe the conditions of attraction and repulsion. Once they have established rules for forces in terms of polar alignment and distance between magnets, students will use iron filings to observe the invisible field lines. In order to prevent direct contact between iron filings and magnets, students place magnets in bag so that they lie flat on the table at sufficient distance so as not to move each other. Place a piece of paper over the magnets and sprinkle with iron filings. Record observations of the fields in the appropriate location in the Student Activity Journal and answer related questions.

ref + explain →

Activity B: Magnetic field lines of the Earth and the Sun

Overview: Students investigate model spheres of ~~the Earth and Sun which~~ contain embedded magnets to compare and contrast the magnetism of the Earth and the Sun.

← avail from where?

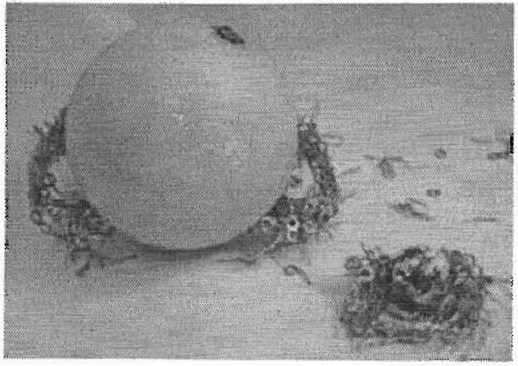


Image Credits

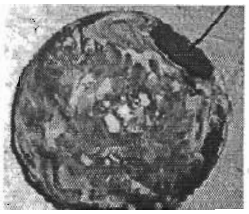
Objectives:

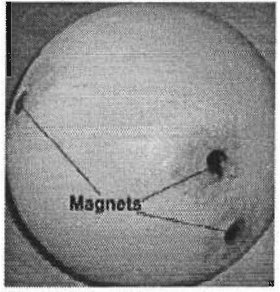
1. Students will recognize the Earth as a dipole magnet
2. Students will understand that sunspots consist of pairs of opposing poles

Materials:

For each student group-

- 1 styrofoam Earth with a south magnetic pole at the geographic north and a north magnetic pole at geographic south,
- 1 styrofoam sun with 3 pairs of embedded sunspots located near the equator arranged with opposing poles.
- A small cup of "field bits" made from closed staples
- A "field detector" made from a paper clip, pencil eraser and push pin.





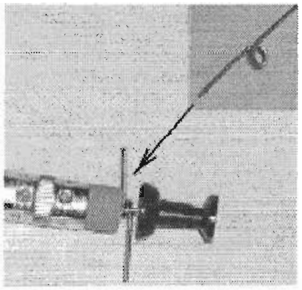


image credit?

Procedure:

Explore each sphere using the "field detector". Ask students to predict the shape of the field between the poles. Verify predictions using "field bits" to illustrate field in three dimensions. Students will compare and contrast the simplified fields of the Sun and Earth in the Student Activity Journal.

Activity C: Earth's field through history

Overview: Using reading material provided students explore historical evidence from geologists to gain an understanding of magnetic reversals throughout the Earth's history.

Objectives:

1. Students will recognize that evidence of the Earth's magnetic field is recorded in rocks at the Earth's surface.
2. Students will be able to identify methods for measuring changes in the Earth's field.
3. Students will recognize that the Earth's magnetic field has experienced several magnetic reversals throughout history.

Materials:

Student review written material provided. Additional web resources are provided for extensions of learning.

Procedure:

Students will read the background material and explore supporting evidence to make generalizations about the history of the Earth's magnetic field.

Activity D: Representing the Earth's Magnetosphere and the Heliosphere

Overview: Students use NASA's Heliophysics website to determine the meaning of the terms, magnetosphere, ionosphere and heliosphere.

Objectives:

1. Students will be able to identify magnetosphere as the area influenced by a planets magnetic field.
2. Students will be able to identify the heliosphere as the area influence by the Sun's magnetic field.

Materials:

Web-based investigation

Procedure:

Students will answer questions relating to the heliosphere and the Earth's magnetosphere based on information gathered through an interactive web quest.

STAGE TWO – Processes behind the magnetic field

Students build upon the knowledge of magnetism to include electromagnetic induction. Connections between lab based discoveries will be made to large scale processes at a basic level. Students develop a rudimentary understanding of Faraday's dynamo as a model for the process Earth's magnetic field.

unclear here

Activity E: Magnetic field caused by a current carrying wire

Overview: Students explore the effect of a current carrying wire on a compass.

Objectives:

1. Students will recognize that a current carrying wire creates a magnetic field.

Materials: Battery with holder, light-bulb with receptacle, compass wrapped with wire, 3 wires with alligator clips

Procedure: Students connect a compass wrapped with wire and light-bulb in a holder in series with a 1.5 V battery. The light-bulb is used to verify that current is traveling through the wire. Students record observations about the behavior of the compass with and without current in the Student Activity Journal.

Activity F: Induction of current by movement in a magnetic field

Overview: Students move a large extension cord within the Earth's magnetic field and observe the induced current at different orientations and speeds.

Objectives: Students will recognize that movement of a conducting wire perpendicular to a magnetic field will produce a current in the wire.

Materials: 100 foot extension cord, ammeter measuring in micro amperes, 2 wires with alligator clips or appropriate attachment points for ammeter, compass

Procedure:

Attach the ground prong of extension cord with an alligator clip to one ammeter terminal. Insert an alligator clip into the ground receptacle of the other side of the cord and attach to the other ammeter terminal. In order to keep the meter stable have someone stand on the extension cord between the jump rope and the meter. (See image below). Align the remaining cord perpendicular to the extension cord and spin the cord as a jump rope at high speed and low speed. Record observations about deflection of ammeter needle at each speed. Repeat process with cord spinning parallel to the Earth's magnetic field at each rate.

cite a pub (eg TPT)

image credits

Activity G: Electromagnetic induction within the Earth

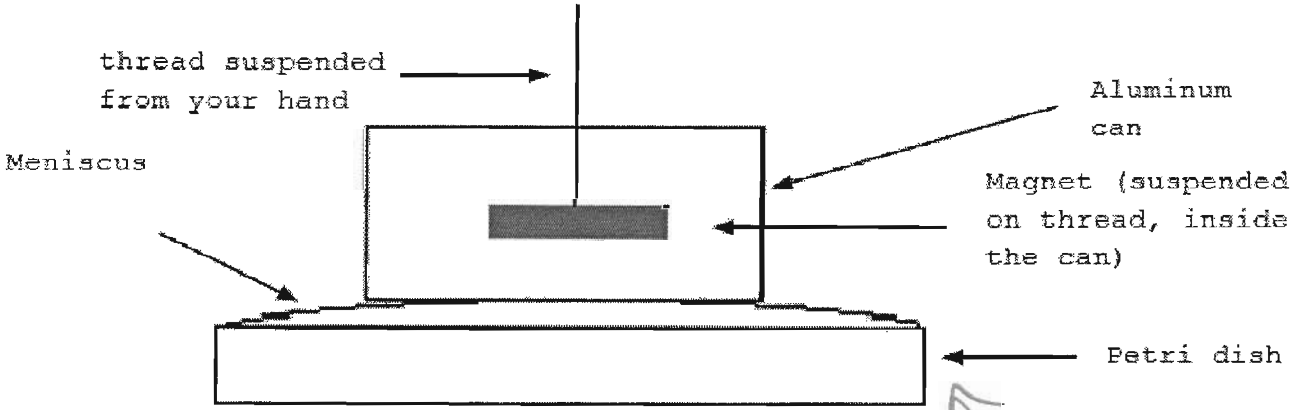
Overview: Students conduct a simple experiment with a spinning magnet lowered into a floating aluminum can causing it to rotate opposite to the to observe Lenz's law and relate finding to movement of material within the Earth that causes Earth's magnetic field.

Objectives: Students will understand that the spinning magnet creates an alternating magnetic field. Students will be able to further infer that a moving magnetic field induces a current within the aluminum can, which in turn creates an induced magnetic field within the can. The can moves as a result of the interaction between the two magnetic fields.

Students will know Lenz's Law: *"An induced electromotive force generates a current that induces a counter magnetic field that opposes the magnetic field generating the current."*

Materials: Petri dish filled with water, small cylindrical magnet tied in center to a thread, tray for water overflow, water, aluminum can like one used for cat food.

Procedure: Set up the petri dish and aluminum can as shown in the diagram below. Holding magnet above can, begin spinning by rolling string in fingers. Lower spinning string into can slowly. (Several attempts may be necessary). The can will spin in the opposite direction of spinning magnet due to induced magnetic field.



Students will answer questions in Student Activity Journal and relate the observations to a timeline of discoveries within the magnetic field.

http://www.nasa.gov/vision/earth/lookingatearth/29dec_magneticfield.html

more is this image from here?

Student Activity Journal

explain further please

Day 1: Magnetism and the Earth

Activity A: Exploring Magnetic Fields

Materials: Two bar magnets, iron filings in a shaker, plastic bag, sheet of paper, compass

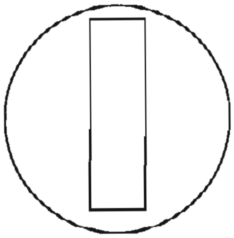
1. While maintaining contact with each magnet, orient magnets so that like poles are facing each other about an inch apart. Release your hand from one magnet. Describe your observations.

2. Repeat the previous steps but place the magnets at twice the distance. How do your results differ from step one?

3. While maintaining contact with each magnet, orient magnets so that opposite poles are facing each other about an inch apart. Release your hand from one magnet. How do your results differ from step one?

4. It is often stated that the Earth is a bar magnet. When you use a compass near the surface of the Earth, the compass is a free magnet and the Earth is the fixed magnet. Which pole of the compass is attracted to the North Pole?

5. On the sphere at right label the poles of "magnet Earth".



6. Place a single magnet in plastic bag. Smooth the bag and cover with a sheet of paper. Sprinkle iron filings from the shaker onto the paper above the magnet. Draw a rough sketch of the pattern that appears.

7. Repeat the previous steps using two magnets in the bag oriented according to diagrams below. Draw a rough sketch of the pattern that appears for each.

Activity B: Modeling the magnetic fields of the Earth and the Sun

Your task is to investigate the shape of the field around the Earth and around the sun using models made from polystyrene balls and embedded neodymium magnets. Closed staples or other material will serve as the "field bits" to illustrate the characteristic shapes of each of the fields. A simple "field meter" consisting of a modified paperclip will be used to make further observations of the fields.

8. Using your "field meter" predict the shape of the fields around each. Draw a rough sketch or describe your predictions.

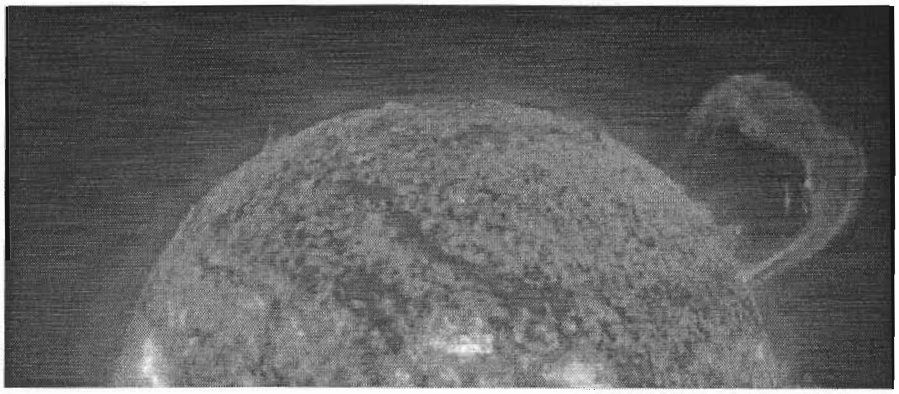
9. Using the "field bits" verify the shape and structure of the fields around the Sun and the Earth. Compare and contrast your observations of the shape for each field.

10. Using a compass or a labeled magnet determine polarity of the paired magnets in the sun.

11. Using your "field meter" determine how the far away the fields reach. How does the strength of the field change with distance?

The shapes observed when investigating the model of the sun are known as prominences which consist of plasma. Plasma is a gas comprised of charged particles moving throughout. With what common phenomena are the prominences associated on the surface of the Sun?

How are these phenomena represented in the model?



12. Summarize the characteristics of these prominences in terms of magnetic polarity.

Activity C: Earth's field through history

Timeline of discovery:

Humans have been observing the magnetic field for over 2000 years. The dates below summarize milestones of discovery that occurred. These observations form a framework for explaining the processes that create the Earth's magnetic field. As you read through this timeline, devise questions that might be of interest to a geo-physicist tasked with explaining the process behind the Earth's magnetic field.

1600-1046 BCE – Houses built during the Shang Dynasty were aligned to the magnetic north.

800 BCE – Chinese fortune tellers use lodestone as a trick for prediction

600 BCE – Earliest references in Greek history to magnetism in the region of Magnesia, Asia Minor

200 BCE – Earliest known compass created in China

1000AD – Navigation with compasses in China

1300 – Widespread use of compasses for Navigation. During this time it was widely observed that compasses did not align with true north and variations in different locations.

1600 – Sir William Gilbert published De Magnete. The book concluded that the Earth is a giant magnet with a fixed magnetic field.

1635 – Henry Gellibrand discovered that the Earth's magnetic field was not fixed citing evidence that the declination of London had changed significantly in 12 years and that the changes around the world were not consistent with a constant field.

1698 – Edmund Halley commissioned to conduct a magnetic survey of the Atlantic Ocean producing the first known map of magnetic declination. This map was used for nearly a century.

1830's – Carl Friedrich Gauss, Wilhem Weber and Alexander von Humboldt created the Magnetic Union, a series of informal research stations in Europe for the purpose of measuring the magnetic field. They developed a method of measuring the strength of the Field.

1831- The true magnetic north pole was discovered by James Clark Ross

1839 – Magnetic Crusade was established to set up magnetic observatories throughout the British Empire

1840-1870 – Sir Edward Sabine, director of the Magnetic Crusade, observed that magnetic disturbances in the Earth's field followed an eleven year cycle similar to the cycle of sunspots observed by Heinrich Schwabe.

1904 – Roald Amundsen determined that the magnetic north pole had moved approximately 30 km since discovery 1831.

1906 – Bernard Bruhnes and P. David discovered rocks containing magnetite with a reversed polarity from the current magnetic field. Magnetite in lava retains the direction and strength of the Earth's magnetic field as it cools. This discovery provides evidence that the Earth's field has flipped.

1926 – Evidence of magnetic reversals in rock is discovered all over the world in rocks of varying age suggesting that reversals have occurred many times in the history of the Earth. Through dating of rocks it was discovered that in the last 10 million years the average interval for reversal has been 250,000 years with the last reversal occurring 780,000 years ago.

1960-Present – Satellites in addition to Earth based magnetic observatories have continued to map the magnetic field and make predictions

13. In recent decades scientists have successfully modeled the Earth's magnetic field using computer simulations. Based on the observations and evidence provided in the above timeline, state three characteristics of the Earth's magnetic field that would need to be addressed by any effective model.

14. In addition to knowing the characteristics of the Earth's magnetic field, scientists need to understand the structure of the Earth in order to explain the origins of the magnetism. An essential discovery toward developing a full picture of the Earth's interior arose from the work of seismologists between 1906 and 1940. Based on your prior knowledge from Earth Science class, how do the behaviors of s and p waves generated during an earthquake help us determine the structure and composition of the Earth's interior?

(For helpful a helpful reminder see the animation and explanation provided at this link. http://www.classzone.com/books/earth_science/terc/content/visualizations/es1009/es1009page01.cfm)

Activity D: Representing the Earth's Magnetosphere and the Heliosphere

Understanding the Earth's space environment is important for maintaining satellite technology and protecting electronic devices on Earth. The National Aeronautics Space Administration (NASA) devotes significant resources to predicting solar storm events that may influence Earth's environment. As we have already learned the Earth and the Sun both possess magnetic fields. When analyzing the magnetic interactions of the planets and the sun it is important to recognize that both are in constant motion as they move through space. Scientists have special terms to define the magnetic fields of planets and stars.

Use the websites listed below in conjunction with embedded links to answer the questions listed below:

http://helios.gsfc.nasa.gov/magnet.html

http://helios.gsfc.nasa.gov/heliosph.html

http://science.nasa.gov/heliophysics/focus-areas/

15. What is the solar wind? What are the components of solar wind?

16. Define the terms heliosphere and heliopause. Destinguish between these two regions of space.

17. What is the term for the region around a planet where the magnetic field interacts with the solar wind? How does this region differ from the magnetic field around a stationary bar magnet?

Day 2: Electromagnetic Induction in the Earth's Field

As we have seen in previous activities, the Sun and the Earth both have active magnetic fields. The Earth's magnetic field is similar to that of a bar magnet. The Sun's magnet field is much less uniform with many paired poles in the form of sun spots. Sun spots consist of opposing magnetic poles with a prominence of plasma arching between them. Plasma is a gas containing charged particles. We have observed that moving charged particles create a magnetic field. In the following investigations we will further investigate the Earth's magnetic field.

Activity E: Magnetic field around a current carrying wire

You will be provided with a compass wrapped in a coil of wire. Attach the compass in series with a small bulb to a 1.5 V source of potential difference.

18. Before turning on the circuit, orient the compass so that the wire aligns with the magnet. Connect the circuit. What happens to the compass when the current passes through the wire?

19. What conclusions can you make about a current carrying wire based on your observation?

Activity F: Induction of current by movement in a magnetic field

Your task is to create a current in a jump rope using the magnetic field of the Earth. Using a 100 foot extension cord to form a closed loop attached to an ammeter that measures in microampere (a device used for measuring current), we will form a jump rope that will be rotated in different orientations to the magnetic field. Attach the ammeter to the extension cord via the grounding prong and receptacle. Allow several feet of cord to lay flat on the ground and have students stand on each cord to prevent movement on the ammeter and attachment points. The remaining cord will be used as the jump rope. Using a compass, orient the jump rope perpendicular to the magnetic field and rotate the cord as a jump rope. Take measurements from the ammeter at two different spin rates. Repeat the experiment with the cord aligned to the magnetic field at two different speeds. Fill in data below.

	Slow Rotation	Fast Rotation
Perpendicular to the magnetic field		
Aligned with the magnetic field		

20. Based on your observations, does the speed of rotation influence the current?

21. Explain why the needle of the ammeter moves when the cord is rotated.

22. What orientation to the field causes the maximum deflection of the ammeter needle?

23. Explain why the orientation of the jump rope to the Earth's magnetic field influences the magnitude of the reading.

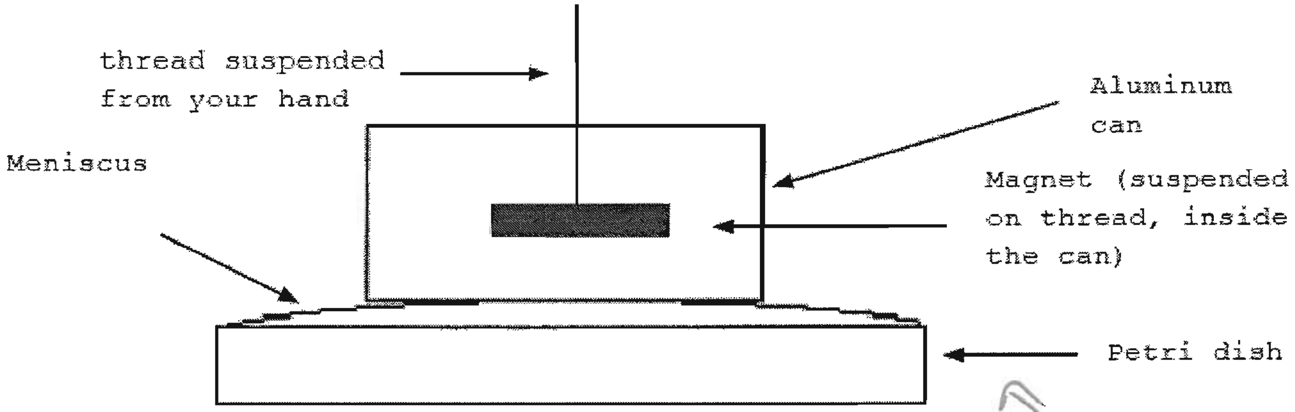
Activity G:

The following activity provides a simple version of the physics behind the Earth's magnetic field.

Set-up the equipment as follows.

1. Place the petri dish on paper towel or shallow tray and fill so that a meniscus forms at the top.
2. Float the aluminum can on the meniscus.

3. Lower the small bar magnet into the center of the aluminum can and spin the magnet by rotating the string in your fingers.
4. Note how the motion of the magnet influences the motion of the can.



24. At the outset of the experiment is the can magnetic? Explain your reasoning. unclear

cite an article (TPT)
better photo

25. Describe the motion of the can when the rotating magnet is lowered into the center.

26. Explain the process which caused the can to move based on your knowledge of the electromagnetic induction.

The Earth's magnetic field is thought to be caused by a similar effect as observed in Lenz's Law. Using your knowledge of the structure of the Earth's interior and your knowledge of electromagnetic induction explain how the Earth maintains a magnetic field. If you need a refresher on the Earth's interior or help with this problem see the following resources.
http://www.nasa.gov/vision/earth/lookingatearth/29dec_magneticfield.html ??

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http://cse.ssl.berkeley.edu

Incmple

Separate activities
from Curric sequence

Put activities
into appendices

attribute activities & figs
cite
repl URLs.

Repeat + Discuss
conclusions
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CONCLUSIONS??