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Teachers in Industry for Educational Support

Magnetic Explorations

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Magnetic Exploration
Curriculum Unit Overview

Summary

The microwave, CD player, VCR, DVD and the automobile are an integral part of everyday life for most students. Very few however realize that magnets are essential for the operation of these devices. Careers involved with these devices and many other similar ones involve the study of magnetism. All motors and generators contain magnets. Electrical engineers and Material Science engineers would top the list of careers that need to study magnetism. Other careers would include electrical technicians, automotive repair technicians, medical technicians. In this unit we are trying to interest students in these careers by generating enthusiasm in the study of magnets.

This unit is designed for 11th and 12th graders. The time required would be three weeks of regular 50 minute class time.

Big Picture

THIS WILL GET YOU "HOOKED"
Magnetic properties / fields

Within this activity we will look at several materials and examine its ability to exert a force.

Materials:
- Bar magnets(Preferred to be marked “N” and “S” poles)
- Container of iron filings
- Sheet of transparency paper(notebook paper will also work)
- Magnetite mineral/Lodestone
- Magnetic compass
- Collection of magnetic/non-magnetic materials

Instructions: 1) Obtain from the instructor several materials. You will need to ask the instructor for a magnetic compass. Using the compass as your indicator determine if your collection of materials is magnetic or not. Observe and record which samples are magnetic.

SHOW YOUR RESULTS TO THE INSTRUCTOR

2) Obtain from the instructor a piece of transparency paper, a bar magnet and center the bar magnet underneath a piece of clear paper.
Lightly sprinkle the iron filings on the magnet and allow them to extend several centimeters beyond the edge of the magnet. Tap the edge of the paper and observe what happens to the iron filings. Explain your results. Make a drawing of the filings pattern.

Place the north pole of a second magnet about four centimeters from the north pole of our first magnet. Slide the transparency paper over both magnets and allow the filings to settle over both magnets.

WHAT DO YOU OBSERVE?

MAKE A DRAWING OF HOW THE FILINGS INTERACT WITH THE TWO BAR MAGNETS.

Turn the magnets so that each magnet has is oppositely aligned for each pole. That is to say the magnet on the left has its north pole is facing the south pole for the second magnet on the right.

WHAT DO YOU OBSERVE?

MAKE A DRAWING OF WHAT YOU SEE.

Next, place each magnet so that one is atop of the other (look at drawing below). Also place the pole of each magnet beside each other (N – N , S – S).
Position the magnets so that they are about 7 cm. apart from each other. Using your transparency sheet,
place it on top of the magnets and sprinkle the filings on and around each magnet. State what you observe and make a drawing.

Obtain from the instructor a sample of magnetite or lodestone. What do you think is the significance of this material? Does it have any bearing on the earth's magnetic field? Explain how.

Preparation for the Unit

Students should be introduced to this unit by the hook activity. The ALT activities will lead the student through the study of magnetism. The student will be given information on magnetic forces, magnetic fields, transformers, motors and generators that lead to and then connect the ALT activities. Students will need science lab stations along with computers and Pasco lab equipment. Other materials required are listed in the ALT activities.

(Unit's Title)
Curriculum Unit Summary

MATHEMATICS	SCIENCE	TECHNOLOGY
ALT 1 – Equations Involving Magnetic Forces- **The students will do a worksheet, solving problems with magnetic forces and magnetic fields.**	**ALT 1 Investigating magnetic fields of force-** **This activity will allow the student to plot points and determine how a magnetic field will appear.**	**ALT 1 – Using the Internet to Explore Properties of Magnets—Students will use the web to answer questions about magnets and study an experiment.**
ALT 2 – Transformer- **Students will do a Pasco lab experiment and analyze data involving voltage of the primary and secondary coils.**	**ALT 2 – Making an Electromagnet -** **This activity will have the student create an electromagnet and have the new magnet accomplish a task that use this magnetic force.**	**ALT 2 – Magnetic Field Strength Relative To Distance—Students will use computer software to measure and display the relationship between a magnetic field and the distance from an object to a magnet.**
ALT 3 – Graphing- **Students will graph data of magnetic fields and forces.**	**ALT 3 - Electromagnetic Induction-** **Within this lab activity, the students manipulate coils of wire and magnets to see a relationship between electric current and magnetism**	**ALT 3 – The Magnetic Field of a Slinky—Students will use CBL's and graphing calculators to study a solenoid and the relationship between current and magnetic field**

Transfer Activity

The students will use technology to study careers that would use magnetism, specifically focusing on the math and science skills necessary for these careers.

Section One: MATHEMATICS

ALT ONE: Equations Involving Magnetic Forces

Summary

Students will use magnetic force equations to solve problems.

Competencies

1. The student will be able to set up and solve linear equations.
2. The student will be able to model real-world phenomena with a variety of functions.

Time

One class period of 50 minutes is needed.

Materials

Worksheet ALT 1
Physics textbook to review equations if needed.

Instructions

1. You will be divided into groups of three.
2. You will need to review physics equations for magnetic forces, magnetic fields and transformers. Use either your textbook or class notes.
3. You will be given Worksheet: ALT 1 Magnetic Forces and Fields
4. You must work with your group to provide answers to the given problems.
5. You will turn in a completed worksheet.

Evaluation/Assessment of Student's Competency

1. Students will be given 5 points of 20 points if they worked well with their group.
2. Students will be given 5 of 20 points for completing the worksheet.
3. Students will be given 10 of 20 points for correct answers to the worksheet.

Closure

Students will be reminded of the transformer equations. In the next lab to be performed, students will be calculating the number of turns on the secondary when the voltage is known.

Equations Involving Magnetic Forces ALT One: Handout One

PHYSICS MAGNETISM WORKSHEET

PHYSICS MAGNETISM WORKSHEET NAME ________________________

1. A proton is moving at right angles to a magnetic field of 1.5 T. Find the speed of the proton if the magnetic force on it has a magnitude of 5.6×10^{-11} N.

2. A proton moves with a speed of 2×10^4 m/s at an angle of 43 degrees with respect to the direction of a magnetic field of 0.4 T in the + x direction. Find a) the magnitude of the magnetic force on the proton and b) the acceleration of the proton.

3. A wire carries a current of 8 A in a direction of 35 degrees with respect to the direction of a magnetic field of strength 0.4 T. Find the magnetic force on a 4.6 m length of wire.

4. A proton moving with a speed of 5×10^6 m/s through a magnetic field of 2.0 T experiences a magnetic force of $3x10^{-12}$ N. Find the angle between the proton's velocity and the field.

5. A vertical wire carries a current of 12 A directed upward at a location where the magnetic field of the earth is horizontal and has a value of 0.5 G. If the wire is 15 m long, find the magnetic and direction of the magnetic force on it.

6. A step-down transformer has 7200 turns on its primary and 120 turns on its secondary. The voltage across the primary is 7600 V. a) Find the voltage across the secondary. B) The current in the secondary is 35 A. Find the current in the secondary.

7. An ideal step-up transformer's primary circuit has 400 turns. Its secondary circuit has 14,000 turns. The primary is connected to an AC generator having an EMF of 120 V. a) Calculate the emf of the secondary. B) Find the current in the primary if the current in the secondary is 3.0 A. c) Find the power drawn by the primary and power supplied by the secondary?

Section One: MATHEMATICS

ALT TWO: The Transformer

Summary

Students will use Pasco Lab P42 : Transformer. Students will perform an experiment and learn how a transformer is used to increase or decrease an AC voltage. Students will use equations to do calculations.

Competencies

1. Students will be able to model real-world phenomena with a variety of functions.
2. Students will be able to simplify algebraic expressions.
3. Students will be able to solve trigonometric equations and verify trigonometric identities graphically and analytically.

Time

One 50 minute lab period.

Materials

Computer, monitor, printer
Pasco Science Workshop Interface
Pasco Science Workshop software
Power Amplifier
Pasco Voltage Sensor
2 patch cords
Primary and secondary coils
Iron core

Instructions

1. Students will be working in groups of four.

2. Connect the Pasco interface to the computer. Connect the power amplifier DIN plug into analog channel A. Connect the voltage sensor DIN plug into analog channel B.

3. Read the explanation and directions for the experiment from the experiment window for P42.
4. Build a step-up transformer, using banana plug patch cords to connect the inner coil to the output jacks of the power amplifier. Connect the voltage sensor's banana plugs to the outer coil. Put the inner coil completely inside the outer coil. Put the iron core as far into the inner coil as it will go.
5. Click the MON button to begin monitoring data. Observe the curve of the voltage vs time graph. Identify the curve. Using the Smart Cursor to go to the peak of the top voltage, read the value. Read the lower voltage for the same time. Record both voltages.
6. Using the known number of coils of the primary, N_p, calculate the number of coils on the secondary, N_s, using the equation

$$N_p/N_s = Vp/V_s$$

7. Compare the value the coils of the secondary to the known number of coils on the secondary.
8. Calculate the ratio of current in the primary to the current in the secondary.
9. Construct a chart with the given data and calculations.
10. Repeat the experiment removing the iron core from the coils.
11. Write your lab report including an Objective, Chart of Data and question answers.
12. Questions:
    1. How did your calculated value for turns on the secondary compare with the known value? Find the percentage error.
    2. If there was a percentage error, give two reasons why the two values for turns on the secondary were not the same.
    3. What effect did removing the core from the coils have on the value of the voltage in the secondary?

Evaluation/Assessment of Student's Competency

Student participation in the laboratory procedure will be assessed. Giving participation points.
Lab Report will be graded according to the following criteria.

- 2 points for a correct objective.
- 10 points for a completed data chart.
- 2 points for correctness of the data
- 3 points for correct answers to the questions.

Closure

The graph will be discussed and acknowledged as a trig function. Correct methods of graphing will be extracted from student answers, which leads to the next ALT 3 where students will be graphing given data.

Section One: MATHEMATICS

ALT THREE : Graphing Activity

Summary

Students will graph given data of magnetic fields and magnetic forces.

Competencies

1. The student will be able to read, interpret, and use tables, charts and graphs to identify patterns….
2. The student will be able to graph linear functions.

Time

One class period of 50 minutes is needed.

Materials

Graph paper
Ruler
Worksheet ALT 3: Graphing

Instructions

1. You will be given a worksheet and a sheet of graph paper.
2. You will work in groups of three, although each of you must turn in the graph and worksheet.
3. You will graph the given data and then answer the questions.
4. All work should be turned in by the end of the period.

Evaluation/Assessment of Student's Competency

The graphing activity will be graded according to the following rubric: 10 points for the correct linear curve
2 points for title, and axes correctly labeled
2 points for each of the questions answered correctly
total: 20 points

Closure

Discuss the equation $F = qvB$ and the relationship of this force to the distorted force on a conducting coil in a magnetic field. This leads to the discussion and demonstration of the motor. This also leads to the transfer activity of careers using motors.

MATHEMATICS ALT Three: Handout One

GRAPHING ACTIVITY

You will be given a worksheet and a sheet of graph paper. You will work in groups of three, although each of you must turn in the graph and worksheet. You will graph the given data and then answer the questions. All work should be turned in by the end of the period.

Problem Statement:
A proton is placed in magnetic fields of varying strengths. As a result of the varying fields, the proton experiences different magnetic forces, as indicated in the table below. Assume the speed of the proton remains the same and it is traveling perpendicular to the magnetic field.

Magnetic Field B	Force F
3.2×10^{-2} T	5.78×10^{-16} N
1.3×10^{-1} T	2.31×10^{-15} N
1.6×10^{-2} T	2.89×10^{-16} N
6.4×10^{-2} T	1.16×10^{-15} N
9.6×10^{-2} T	1.73×10^{-16} N

1) Graph the given data with the magnetic field B as the independent variable.
2) Draw the best fit curve.
3) Find the slope of the line.
4) Find the equation for this situation.
5) What does the slope of the line indicate?
6) Find the speed of the proton.

Section Two: SCIENCE

ALT ONE – Investigating Magnetic Fields of Force

Summary/Competencies

The student will demonstrate the ability to read a magnetic compass.
The student is to plot several points on paper that are associated with the compass.
As the points are connected, it should be clear that the lines drawn would determine a magnetic field.

Time

60 minutes

Materials

- two bar magnets
- pencil
- unlined paper

Instructions

Place one bar magnet in the center of a piece of notebook paper. Secure the magnet to the paper so it stays in place during the whole activity.

Place the compass at one end of the bar magnet about 2 cm. away.

(BEFORE YOU PROCEED, YOU NEED TO UNDERSTAND HOW THE COMPASS NEEDLE FUNCTIONS WITHIN A MAGNETIC FIELD)

Make a pencil dot on the paper at the position of both ends of the compass needle.

Move the compass so the "north" end of the needle sits over top of the outmost end of the compass needle of your previous position. Make a dot at the position on the paper where the south end of the needle sits.

Continue this pattern until the your markings move off the paper or return to the opposite end of the magnet. Connect the dots when you finish.

Move the compass so it will be positioned on the another point of the magnet.

Repeat the same procedure but start at the other end of the magnet. Make sure to connect the dots when you finish a particular grouping. Try and form around seven or eight patterns of lines.

Evaluation/Assessment

The student is to demonstrate to the instructor how the compass will function. Questions pertaining to polarity will be asked and answered with reasonable accuracy before the student/team moves on.

As the student continues through the activity, he/she will demonstrate a pattern of lines. This pattern is to represent the field around the magnet.

Closure

These lines will show to the student that they can influence materials that come in contact with them. The next sequence will be to show a use for this force.

Section Two: SCIENCE

ALT TWO – Making an Electromagnet

Summary

With the knowledge gained from previous activities, the student will build a configuration that allows the effects of an electrical current to make a magnet.

Competencies

The student will relate the creation of the magnetic field within the electrical flow.
The student will demonstrate the ability of the newly-made electromagnet to attract magnetic materials
The student will determine the strength of the electromagnetic by the number of paper clips picked up.

Time

100 minutes

Materials

- Nails (should be made of iron)
- One meter length of Bell wire(with insulation intact)
- Two "D" size dry cells
- Paper clips
- Magnetic compass
- Pencil/paper

Instructions

The insulation at the ends of the wires will need to be stripped back to expose about 2 cm. of copper wire. Attach each end of the wire to each post of your dry cell. Suspend the wire into a vertical position and move your magnetic compass around the wire.(DO NOT LEAVE THE WIRES HOOKED UP FOR MORE THAN 1-MINUTE AT ONE TIME – THE WIRES WILL OVER-HEAT). Does the wire have any influence on the compass? Test to see which of the materials will it keep if any. Record your observations.

Hold four ten-cm. nails together and neatly wrap the wire around the nails without over-lapping. Leave about 10 cm. of the wire at each end of our sections of wire.

Now take the longer of the two ends of wire and wrap it over top of the first windings to make a second layer. Test the strength of the electromagnet by how many paperclips it can pick up and suspend it the air.

Carefully remove two of the nails. Record the number of paperclips it can suspend. Keep removing nails until it cannot suspend any of the paperclips.

Evaluation / Assessment

As the student creates a connection through the dry cell, the wire act like a magnet and attract one of the poles of the magnetic compass.

The student can demonstrate the electromagnet's capabilities by picking up more and more paperclips.
A modification to that theme would be to remove some of the nails and still be able to accomplish the same task.

Closure

As the students accomplish this task, a understanding will be gained that electrical force will be able to accomplish magnetic force. This will be of value when the student will later design a plan to build a electric motor.

Section Two: SCIENCE

ALT THREE - The Induction of Electrical Current

Summary

Within this activity the students will investigate the connection between magnetism and electricity. They will need to manipulate the coils of wire and magnets to accomplish the task. Hopefully, they will see a connection between the use of magnetism and the creation of electricity.

Competencies

- The student will need to assemble the coils of wire.
- The student will need to manipulate the coils of wire with the bar magnet to achieve the desired effect
- The student will observe the galvanometer and record any changes that occur.
- The student will gain an understanding between the use of magnetic force and the ability to generate electricity.

Time

2 hours

Materials

- Segments of wire (50 cm. length)
- Galvanometer
- Two bar magnets (ferromagnetic)

Instructions

1) The student will need to obtain three segments of wire from their instructor. Each segment will be coiled around the three middle fingers of the student. You will need to make the following coils of wire for your lab; one single loop coil, one coil with 25 turns around your fingers, and one coil with 100 turns around your fingers. The ends of the wire will need to have the insulation stripped away. You should secure the loops by the twisting small segments of the ends around the loops.

2) Attach the single loop of wire to the galvanometer. Move the magnet through center of the single loop of wire. Record the observations on the data sheet.
   SHOW YOUR OBSERVATIONS TO THE INSTRUCTOR
3) Move the galvanometer connections to the 25-turn coil of wire. Thrust the magnet through the new coil. Record observations.
4) Move the galvanometer to the 100-coil of wire; thrust the North Pole of the magnet into the coil. Observe the galvanometer needle.
5) Leaving the connections the same on the galvanometer, move the bar magnet so that the South Pole end of the magnet is the first to go into the coil. Observe the movement of the needle.
6) Place two magnets together. Make sure that the two poles of each are aligned north with north and south with south. Move them through the 100 turn coil and observe the deflection of the needle. Slowly pull the bars through. Try different rates of speed and observe the amount of deflection.
7) Repeat the procedure that is similar to number two but move the bar magnet back and forth. Observe what effect that has on the galvanometer.

Observations:

Make observations of needle deflections when the magnet is thrust into single loop of wire.

- Observations of needle deflection when the magnet is thrust into the 25 turn coil of wire.
- Observations of needle deflection when the magnet is thrust into the 100 turn coil of wire.
- Observations when the magnet is pulled into and out of the coil.
- Observations of needle deflection when two magnets are moved into the 100-turn coil at different velocities.

Evaluation/Assessment

1) Why did the galvanometer needle deflect in one direction when the magnet went into the coil and in the opposite direction when the magnet was pulled back out?
2) Summarize the factors that affect the amount of current and EMF induced by the magnetic field?
3) The equation for EMF is given as; EMF=Blv, where B is magnetic induction, l is the length of the wire in the magnetic field, and v is the velocity of the wire with

respect to the field. Explain how your results prove to validate the equation.

Closure

As you develop the connection between magnetism and electricity, an understanding will begin to occur that magnetic forces can generate electricity and vice versa. Also, electromagnetic forces are arranged in a particular manner of attraction and repulsion so that a mechanical motion will be achieved.

Section Three: TECHNOLOGY

ALT ONE: Using the Internet to Learn About Magnets

Summary

Students will use the internet to research properties of magnets and summarize instructions for an experiment.

Competencies

1. Students will browse the internet (given a specific website) to answer specific questions.
2. Students will choose an experiment found on the web and summarize it, including materials needed, specific instructions, and concepts that the experiment illustrates.

Time

This lab will take 1 ½ to 2 hours to complete.

Materials

1. Computer attached to the internet.
2. Computer with a word processor.

Instructions

1. We are going to be working from the "Magnet Man" website. To do this we must do a search for this. Go to www.google.com, which is known as an internet search engine. At the prompt, type in magnet man. You should find the web site, so click on it to enter. (If the website does not show up on this search engine, see the instructor for the actual address.)
2. By searching through this website, find the answers to the attached questions. Write the answers on the sheet. Basically anything that is underlined will take you to another site, and you can back up by using the BACK button on the toolbar.
3. Choose one of the experiments described in the website. Write a summary of the experiment. Your summary should not be as in-depth as the descriptions on the website. It should describe the material required for the experiment, the basic instructions of the experiment, and general concepts illustrated by the experiment.

Evaluation

Students will be evaluated in two ways on this project. First, the questions sheet will be graded for correctness. The experiment summary will be graded for clarity, completeness, and writing correctness.

Closure

In this activity, by using the internet, we learned some interesting properties of magnetism, as well as investigating an experiment dealing with magnets. In the next activity, we will study some properties of magnetism, specifically how magnetic strength is affected by the distance an object is from the source.

ALT One: Handout One

Questions to answer from the website

1. What two ancient civilizations discovered magnetized stones, and what did they call these stones?

2. List three facts about magnetism.

3. List three materials used to make permanent magnets.

4. Approximately where is magnetic north?

5. List two safety considerations when dealing with magnets.

6. How can the strength of an electromagnet be increased or decreased?

7. Name one unit that can be used to measure magnetic flux density.

8. How strong is the Earth's magnetic field?

9. What is a pentomino?

10. Where did the name "magnet" come from?

Section Three: TECHNOLOGY

ALT TWO: Magnetic Field Strength Relative to Distance

Summary

Students will use a Magnetic Field Sensor and computer software to determine the relationship between the magnetic field acting upon on object and the distance that object is from the field.

Competencies

1. Students will successfully set up the computer software.
2. Students will successfully calibrate the sensor.
3. Students will use the sensor and software to collect a sufficient number of data samples.
4. Students will plot the data on a piece of graph paper.
5. Students will determine the type of function that represents the data.
6. Students will use the software to model the function.
7. Students will use the computer graph and the function equation to answer questions.

Time

This lab will take the students 50 minutes to complete.

Materials

1. Computer with Pasco *Science Workshop Software*
2. Magnetic Field Sensor
3. Neodymium disk magnet
4. Meter Stick
5. Graph Paper

Instructions

1. Connect the magnetic field sensor to the computer.
2. Open the *Science Workshop* software for Magnetic Field Strength vs. Distance
3. Calibrate and set up the equipment. Place the meter stick on a flat surface away from the computer. Place the magnetic field sensor so the end of the rod is even with the zero end of the meter stick. Select the AXIAL setting on the Field Sensor. Push the ZERO button to zero the sensor.

4. Now begin recording data. Place the magnet next to the 0.5 cm mark on the meter stick with the north pole facing the sensor. Click the REC button on the software screen to begin collecting data. Enter 0.005 (distance in meters) for the location of the data. Press Enter to record the data.
5. Move the magnet to the 1.0 cm mark of the meter stick. Type in 0.010 as Entry # 2 on the computer. Press Enter to record the data.
6. Continue this process, each time moving the magnet 0.5 cm further from the sensor. Continue recording data until the field reaches about 10 gauss or doesn't change as the distance increases.
7. Click the Stop Sampling button to quit collecting data.
8. Now we will analyze the data. Plot your data points on your graph paper with distance on the horizontal axis and strength on the vertical axis.
9. By looking at your data, determine which type of curve would best fit your data (choose between linear, logarithmic, exponential, power, polynomial, and sine series.) Once you have made this decision, check with your instructor before continuing.
10. We will have the computer graph the function. Click the Statistics button and the Autoscale button so that the graph will fit the data.
11. Click the Statistics Menu button and select Curve Fit, and then select the appropriate curve that you chose in part 9.
12. Use the graph and it's equation to answer the questions below. Answer the questions on a separate sheet of paper and write complete answers.
13. You will turn in a printout of the graph generated by the computer, as well as the answers to the questions.

A. Does the magnetic field strength increase or decrease as the distance from the magnet is increased?
B. Is the relationship between magnetic field strength and distance linear?
C. What would be the magnetic field strength if the distance is 15.5 cm?
D. What would be the distance to produce a strength of 100 gauss?
E. What would be the distance to produce a strength of 50000 gauss? Explain why this is not possible.

Evaluation

The first few competencies will be observable by the instructor. By circulating the room, the teacher will notice if the students are having trouble setting up the equipment or taking the readings. The students will not be graded on this; rather the instructor will assist the students in doing these correctly.

Once the students have plotted their graph and determined the type of function, they must check with the instructor to see if they are correct. If they are incorrect at this point, the instructor will, through the use of leading questions, guide them to the correct function type. This is necessary so that they can be successful in generating the equation and the graph and answering the questions.

The instructor will also assist the students in correctly using the computer software to generate the graph.

The students will turn in the answers to the questions. These will be graded based on their consistency with the graph and equation that was generated. Points will be deducted for poor grammar and spelling.

Closure

In this activity, we learned that magnetic strength is linearly related to the distance an object is from the magnet. In the next activity, we will study how current and the distance between wires affects a magnetic force created by electricity.

Section Three: TECHNOLOGY

ALT THREE: The Magnetic Field of a Slinky

Summary

We will use a slinky to create a solenoid, which is tube made of many turns of wire. When a current passes through the wire, a magnetic field is created inside the solenoid. In this lab we will study the relationship between a magnetic field and the current in the solenoid and the relationship between a magnetic field and the spacing between the turns of the wire.

Competencies

1. Students will correctly set up the lab.
2. Students will determine the relationship between a magnetic field and the current in a solenoid.
3. Students will determine the relationship between a magnetic field and the number of turns per meter in a solenoid.
4. Students will use graphing calculators to record data and create a line of best fit.
5. Students will analyze the lines of best fit to answer questions.

Time

This lab will take 60 to 90 minutes.

Materials

1. TI-82, 83, 86, 89, or 92 calculator
2. Calculator Based Laboratory System
3. PHYSICS program loaded in calculator
4. Vernier Magnetic Field Sensor
5. TI Voltage Probe
6. Slinky
7. Vernier adapter cable
8. Meter stick
9. DC power supply
10. 1-Ω power resistor
11. Cardboard spacers
12. Clip-lead connecting wires
13. Momentary-contact switch
14. Tape and cardboard
15. Graph Paper

16. Data and questions sheet

Instructions

Part One--Initial Setup

1. Stretch the slinky to about one meter in length. The distance between the coils should be about one centimeter. Use a non-conducting material (tape, cardboard, etc.) to hold the slinky at this position.
2. Set up the circuit and equipment. Connect the TI Voltage Probe across the resistor, with the positive (red) lead on the side of the resistor connecting to the positive side of the power supply. Wires with clips on the end should be used to connect to the slinky. The switch should be placed between the resistor and the slinky.
3. Connect the TI Voltage Probe to the CH1 port of the CBL unit. Connect the Vernier Magnetic Field Sensor to the CH2 port of the CBL unit. Set the switch on the sensor to "High."
4. Turn on the CBL unit and the calculator and run the PHYSICS program. Proceed to the MAIN MENU.
5. Set up the calculator for the Voltage Probe and the Magnetic Field Sensor.
6. Monitor the magnetic field from the calculator screen.
7. Turn on the power supply and adjust it so the current is 2.0 A when the switch is closed. Open the switch after the adjustment.

Part Two--How the magnetic field is related to the current

1. Place the field sensor between the turns of the slinky near the center.
2. Set up the calculator for data collection by selecting COLLECT DATA.
3. First collect the data for zero current by pushing TRIGGER button on the CBL while the switch is still open.
4. Now close the switch. Set the current to 0.5 A and push TRIGGER again to record the data.
5. Keep repeating step 5, but increase the current by 0.5 A to a maximum of 2.0 A. After the last entry, select stop.
6. Have the calculator create a plot of the data. Determine the type of relationship and have the calculator create a line of best fit. Copy the graph on the graph paper and record the data in TABLE 1, Magnetic Field Vs. Current. Use the data to answer the questions.

Part Three--How the magnetic field is related to the spacing of the turns

1. You will need to zero the reading each time you move the slinky. To do this, select ZERO PROBES from the MAIN MENU.
2. Set the current to 1.0 A. Record the length of the solenoid and the magnetic field in TABLE 2. Read the magnetic field off of the CH2 line of the calculator. Calculate the number of turns/meter. The number of turns should remain constant.
3. Repeat step 2 for slinkies of length 0.5 m, 1.5 m, and 2.0 m. Make sure you the zero the field each time.
4. Plot on your calculator turns/meter against the magnetic field from TABLE 2. Determine the type of relationship and have the calculator calculate a line of best fit. Sketch the graph on the graph paper, fill in TABLE 3 on the data sheet, and answer the questions below it.

Evaluation

The instructor will assist the students on setting up the equipment correctly so that they can all get started. Students will be evaluated on the neatness and correctness of their graphs and tables, and on the correctness of their answers to the questions.

Closure

Through this activity, we learned that increasing current in a solenoid will increase the magnetic field inside it. In addition, increasing the number of turns per meter will also increase the field.

ALT Three—Handout One

DATA and Questions sheet.

TABLE 1--Magnetic Field vs. Current

Slope	
Intercept	
Length of solenoid (m)	
Number of turns	
Turns/m (m^{-1})	

1. Inspect your graph of magnetic field vs. current. How are the fields related?

2.What does the slope measure?

2. What type of magnetic field would a current of 5.0 A produce? Use your equation to calculate this.

Length of Solenoid(m)	Turns/meter n (m^{-1})	Magnetic Field B (mT)
0.5		
1.0		
1.5		
2.0		

Magnetic Field vs. Turns/meter	
Slope	
Number of turns in slinky	
Current(A)	

1. Look at your graph for turns/meter compared to Field. What kind of relationship is there?
2. What type of field should be produced with 50 turns per meter? Use your equation to calculate.

Transfer Activity

In this activity, students will use technology to investigate careers involving magnetism. Students will need to use the web to locate a company that either makes or uses magnets. They will need to contact this company to find out how to prepare themselves to be a "magnetician." This could include such things as what sort of degrees to obtain in college. Then they will use the web to find a college, and they must determine what sort of classes they would need to take to meet these requirements. They should pay specific attention to the math and science courses required. The students should also determine the type of high school preparation necessary for these courses. They are to summarize this in a short (150-200 word) paper, including the companies and colleges contacted (with websites), the questions asked, and the information obtained.

We will evaluate this based on the quality of their writing and the extent to which they met the above requirements.