5th Grade STEM DESIGN CHALLENGE
CORRESPONDING ENGINEERING DESIGN PROCESS STAGE IN RED

Unit 3: Matter
Topic: Design an Electromagnet Device
Subject/ Grade level: STEM/ Grade 5

Materials:

Per team (suggested size- 3)

- Design logs, 1 per person
- Designing materials (will be decided upon by teams and varies depending on the project they choose)
- A large iron nail (about 3 inches)
- Various other nails
- About 3 feet of THIN COATED copper wire
- Various other gauges of copper wire
- Scissors to strip the wire
- A fresh “D” size battery
- Several paper clips
- “One Page Ad” handout
- “Electromagnets Data Chart” handout –has its own materials list
- 21 Century Skills rubric for grading the project

TEKS

Science

Ⓡ SCI.5.5A Classify matter based on physical properties, including mass, magnetism, physical state solid, liquid, and gas, relative density sinking and floating, solubility in water, and the ability to conduct or insulate thermal energy or electric energy.
*Ⓡ SCI 5.6.A Explore the uses of energy, including mechanical, light, thermal, electrical, and sound energy.

Math

MATH 5.1D Communicate mathematical ideas, reasoning, and their implications using multiple representations, including symbols, diagrams, graphs, and language as appropriate.

MATH 5.1E Create and use representations to organize, record, and communicate mathematical ideas.

ELPS

C1A Use prior knowledge and experiences to understand meanings in English.
C5B Write using newly acquired basic vocabulary and content-based grade-level vocabulary.

CCRS

Science

1C1A Work in teams and share responsibilities, acknowledging, encouraging, and valuing contributions of all team members.
1C2A Use Materials Safety Data Sheet (MSDS) information and demonstrate safe laboratory practices.

Math

1B1A Add, subtract, multiply, and divide real numbers accurately, including irrational numbers, numbers with exponents, and absolute value.

6B3A Calculate, describe, and use the appropriate measure of center (e.g., mean, median, mode) and spread (e.g., range, IQR, percentiles, variance, standard deviation).

Cross-Disciplinary
1C1C Apply previously learned knowledge to new situations.
1E2C Work in small groups to investigate a problem or conduct an experiment.

Lesson objective(s):

Students will design a product that harnesses the power of electromagnetism.

Differentiation strategies to meet diverse learner needs:

1. Implement flexible groups, such as mixed-ability or pairs, during the engineering design process activities.
2. Provide several opportunities for students to repeat and explain directions.
3. Provide written as well oral directions when necessary.
4. Have students draw pictures while interacting with information and textual directions to guide tasks.

IDENTIFY NEED

Introduce the topic in a manner similar to the following:
"Most magnets, like the ones on many refrigerators, cannot be turned off, and are called permanent magnets. Magnets that can be turned on and off are called **ELECTROMAGNETS**. They run on electricity and are only magnetic when the electricity is flowing. The electricity flowing through the wire arranges the molecules in the nail so that they are attracted to certain metals. NEVER put the wires of the electromagnet near a household outlet!"

Design Challenge:
"Today, we are going to become engineers and design our own electromagnet. Working in teams, you will research electromagnets and design a device that uses an electromagnet, or invent a new product. You will then try to convince your clients (in this case, the class) to buy your product."

RESEARCH THE PROBLEM

Have students conduct research on how an electromagnet works and current technologies that use electromagnets.

Kid friendly research on electromagnets
Superior introductions, connects prior knowledge, and an interactive review!
http://www.bbc.co.uk/bitesize/ks3/science/energy_electricity_forces/magnets_electric_effects/activity/
http://www.brainpop.com/technology/energytechnology/electromagnets/

Uses of Electromagnets
http://www.discovery.com/tv-shows/other-shows/videos/extreme-engineering-season-1-shorts-maglev-train.htm
http://www.bbc.co.uk/bitesize/ks3/science/energy_electricity_forces/magnets_electric_effects/revision/5/
http://www.school-for-champions.com/science/electromagnetic_devices.htm#.U2KDFfldXng

Differentiation:
If your school does not have a subscription to BrainPop, show one or both of these high quality videos on electromagnetism as a substitute, or use them for additional reinforcement.
http://www.youtube.com/watch?v=_ygmHnjNYNo
http://www.youtube.com/watch?v=sFC7-WVNUP8

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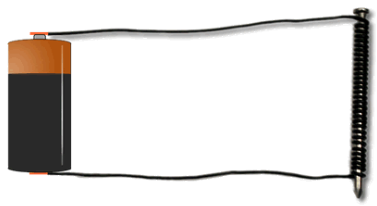
Hands-on Exploration:
Have students write the following hypotheses to prepare for the task.

Hypotheses:
I think that increasing the voltage will __________the electromagnet's strength. (increase, decrease, or not change)
I think that increasing the wire coils will ______________ the electromagnet's strength. (increase, decrease, or not change)
Basic Directions for Making an Electromagnet:

1. Leave about 8 inches of wire loose at one end and wrap most of the rest of the wire around the nail. Try not to overlap the wires.
2. Cut the wire (if needed) so that there is about another 8 inches loose at the other end too.
3. Remove about an inch of the plastic coating from both ends of the wire and attach the one wire to one end of a battery and the other wire to the other end of the battery. See picture below. (It is best to tape the wires to the battery - be careful though, **the wire could get very hot!**)



4. Now you have an ELECTROMAGNET! Put the point of the nail near a few paper clips and it should pick them up!

(Teacher Note: Making an electromagnet uses up the battery somewhat quickly which is why the battery may get warm, so disconnect the wires when you are done exploring.)

Formative Assessment (in their design logs):
Prediction Questions: Teams will predict the answers to the following questions in their design logs.

1. Do you think the number of times you wrap the wire around the nail will affect the electromagnet's strength? Why or why not?
2. Do you think the thickness or length of the nail will affect the electromagnet's strength? Test with other nails.
3. Do you think the thickness of the wire affects the power of the electromagnet? Test with wires of other thicknesses.

Math Connection:
Teams can experiment with the effects of different voltages of batteries using the "Electromagnets Data Chart" handout. Although teams will need to compute averages, it can be addressed simply as a two-step math problem: a sum of two numbers divided by 2. Teams will also display these averages in a line graph. Have students complete the following summarizing statement about this activity:

"Increasing the voltage applied to an electromagnet _____________ its strength."

Differentiation:
Although the hands-on portion is strongly encouraged, some virtual testing of an electromagnet can be completed here. Struggling students may also appreciate the additional practice to better understand the effect of batteries and coils on the strength of the electromagnet.
http://www.harcourtschool.com/activity/electromagnets/

Extension (in their design logs):
Have teams experiment with the different numbers of turns on the electromagnet. What is the magnetic power of a single coil wrapped around a nail? Or 10 coils of the wire? 100 coils? Teams could predict, measure, and compare the electromagnet's "strength" for each of these variations based on how many paper clips are picked up each time. If students do the virtual testing from the Differentiation stage, they will be able to compare "real world" data to simulated data. Teams could talk about why the answers might vary.

DEVELOP POSSIBLE SOLUTIONS

In their teams, students will decide on two designs for consideration as the electromagnet product they will make.

Differentiation:
If students need more guided support for this first project, the class may decide to complete the same design. Decisions related to the planning for and building of the actual design can still vary from team to team thereby allowing for creativity. (**Teacher Note:** It is important for teams to explore several designs at first, narrow down their possibilities to two designs, and then provide justification for their final choice- this is the critical thinking we are trying to develop.)

Kid-friendly Design Ideas for Consideration
http://www.kidslovekits.com/projects/Solenoid/index.html (a door chime)

http://www.kidslovekits.com/projects/Solenoid/index.html (a catapult)

http://www.youtube.com/watch?v=ziWUmIUcR2k (an electric motor)

http://www.wikihow.com/Make-a-Wireless-Telegraph (a telegraph)

(**Teacher Note:** Substitutions can be easily made to designs, e.g., a "switch" can be made with 2 brass fasteners and a paper clip (telegraph); wire strippers can be replaced with just regular scissors (a buzzer). Encourage teams to find alternatives to replace hard-to-find items and to personalize their designs!)

Multiple Speaker Designs
Disposable cup designs
http://www.coolmagnetman.com/magelect.htm (bottom of page)
http://www.sciencefriday.com/educational-resources/make-a-speaker/ (give time for the link to load)

Paper and copper tape design
http://www.youtube.com/watch?v=y1F5Gg4bG3o

Disposable plate design
http://makezine.com/projects/Styrofoam-Plate-Speaker/#.UTo_cTf_c7k
video of above link and excellent explanation here:
http://www.youtube.com/watch?v=EIbzQ_8-aaM&feature=youtu.be (**Teacher Note**: An open flame is NOT needed.)

Formative Assessment (in design logs):
Teams will decide on two different designs, create detailed sketches of them, and develop the directions they will use for each design.

Extension:
Teams can further explore AC/DC current and its effect on the strength of a virtual electromagnet with the following websites:
Kid-friendly explanation of alternating and direct current (AC vs. DC)
http://www.diffen.com/difference/Alternating_Current_vs_Direct_Current

Explore concepts more deeply with a virtual electromagnet and metal filings
http://www.fossweb.com/delegate/ssi-foss-ucm/Contribution%20Folders/FOSS/multimedia/Energy_and_Electromagnetism/electromagnet/electromagnet.html

SELECT THE MOST PROMISING SOLUTION

In their teams, students will decide on the one design from the previous stage to develop. Problem Solution scaffold from previous grade level as model.

Formative Assessment (in design log):
Have teams include a graphic organizer like the one that follows in their design logs to help guide this decision-making process and to evaluate their work for this stage.

Problem	Goal

Possible Solutions	Pros (+) and Cons (-)
#1	+
	-
#2	+
	-

Decision	Reason

Differentiation:
For students that need extra support, the teacher can make the “Select a Solution” template above into a handout to be added to design logs.

CONSTRUCT A PROTOTYPE

Once a design has been selected, teams will begin the build process. Make sure the class led by the teacher sets the norms for the construction process together so that teams clearly understand what is expected of them and why such guidelines, or rules, are needed.

Extension:
In this stage, teams should be given a voice in the construction of the guidelines for the building process. For students that have difficulty understanding why rules are necessary and/or have had limited experience in the rule creation process, question prompts like the following can help:
1. What school safety rules should we be aware of while building our designs? (Constraints)
2. How can your teams safely work with the tools and materials you have chosen? (Materials)
3. What changes might you have to make to your planned design process to ensure the safety of others? (Process)

Formative Assessment:
Teams should create a poster of their electromagnet product and label all parts. Posters should be neat and eye-catching, contain a creative name for their product, and a slogan that convinces consumers to buy the product for its usefulness.

Differentiation:
For teams that are not as artistically creative, or if the teacher does not have a lot of time to allocate to the poster task, students can complete the "One Page Ad" handout, instead.

TEST AND EVALUATE PROTOTYPE

Teams will self-evaluate their product based on pre-established criteria (e.g., electromagnet use, value of the product, and artful display).

Formative Assessment (in design logs):
Teams will evaluate their design process by completing the following questions:

Design Skills
1. Did your design work? (creativity)
2. Did you have any problems building your design? (critical thinking)
3. Did you have to adjust your design in any way? (critical thinking)
4. How could you make your design even better? (creativity)

Extension:
Have teams extend their evaluation of their design process by completing questions about the remaining 2 21st century skills not yet evaluated, like the following: *

Team Skills
5. Did your team work carefully and safely together? (collaboration)
6. Did your team listen to and follow all directions? (communication)
7. Did everyone on your team help clean up each day? (collaboration)

(***Teacher Note:** The teaching of 21 Century Skills has become a national priority. For more information on the 4Cs and a poster to display in your classroom, click here.)
http://www.p21.org/storage/documents/4csposter.pdf

COMMUNICATE THEIR DESIGN

Teams will present their poster and demonstrate their product to the class.

Formative Assessment:
Have teams use the picture scaffold below to review each of the products presented.

(**Teacher Note:** It may be a good idea to project the graphic or make it into a poster to guide this process and to be used whenever teams present a product they have made.)

Differentiation:
For teams with struggling writers, have students write only one sentence responses to each question prompt of the product review.

Extension:
Using an iPad or a cell phone, students could film a commercial to promote their product and include a slogan in their sales pitch.

REDESIGN

After the product shares, the class will come together and share highlights of their reviews with each group and provide any constructive feedback and advice they have to offer. Teams will use this advice to think of ideas for redesigning their product.

Differentiation:
Have reviewing teams meet in small groups with each design team, instead of in a large group forum, to provide personalized feedback and to allow the producers of each product the time necessary to make note of the suggestions and ask clarifying questions as necessary.

Formative Assessment:
After the share session and in their teams, students should respond to the following question prompts in their design log about what they heard:

1. What advice about the product was shared that could be used to redesign it?
2. What advice about the intended client was shared that could be used to redesign the product?

Image of electromagnet from: http://www.sciencebob.com/experiments/electromagnet.php