Lesson Research Proposal for 8th Grade Science
For the lesson on November 7, 2017
Science Conference: "It's Go Time: Science for All"
Instructor: Catherine Flynn
Lesson plan developed by:
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1. Title of the Lesson:

Constructing Models to Explain Energy Concepts

2. Brief Description of the lesson:

In this lesson, the students will create a consensus model for energy transfer based on data they collected from previous lessons. In these previous lessons, students tested models on the interaction of objects as distance between them changed. After completing the final activity, the class will discuss the construction of their model and how it explains the phenomenon. The students have been split into groups from the previous lessons to conduct the experiments and construct models they feel best represent the phenomenon that is occurring when changing distances and interacting with forces.

3. Research Theme:

Through student discourse, teacher questioning, and iterative testing, students will be able to develop and revise models to construct an explanation for phenomenon.

Explanation of Research Theme:

Modeling breaks down components of a phenomenon to help students explain their reasoning of what, how, and why the phenomenon is occurring. It also serves as a tool for making predictions and making sense of the experience. Students will collect data that is relevant and use it to create discussion among peers to explain their thinking. The mathematical relationships are developed through this discussion and comparison of data. Although modeling is a hard practice for students to "grasp", the continued conversation between peers improves their rationale and allows opportunities to advance their ideas. Through student discourse and teacher prompts, they are able to represent and revise their ideas in their models. The explanation of the phenomenon is the ultimate goal.

4. Goals of the Unit:

Students will be able to:

- Independently develop and revise a model based on the observations of the phenomenon of a magnet on a chair with a paperclip on a string;
- Manipulate magnets and other materials to collect observations based on the comparison of the interaction of different shapes, sizes, and strength;
- Gather knowledge and notice trends in their models to develop claims and evidence;
- Suggest possible investigations to gather data to complete their models;

- Use the interactions of the cars to gather data and create a model to explain how the arrangement of objects interacting at a distance changes the different amounts of potential energy stored in the system; and
- Relate the energy of the systems to the phenomenon.

5. Goals of the lesson:

Students will be able to:

- Develop and explain a model to show how distance affects the amount of potential energy in a system;
- Defend their model of potential energy changes at different distances using evidence from previous investigations;
- Through student discourse, with their models, students will press and question each other for understanding to revise their models leading to the development of a consensus model; and
- All learners will be able to contribute to the development, revision, and utilization of the consensus model.

6. Relationship of the Unit to the Standards

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Before	**Description of where we are now**	**After**
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide. [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [Assessment Boundary: Assessment does not include quantitative measurements of energy.]	PS3.C: Relationship Between Energy and Forces When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. Students will be able to develop a model to describe that when the arrangement of objects interacting at a distance changes different amounts of potential energy are stored in the system. When two objects interact each one exerts a force on the other that can cause energy to be transferred to or from the object.	HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects)
3-PS2-3: Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.	PS3.A: Definitions of Energy A system of objects may also contain stored (potential) energy, depending on their relative positions.	HS-PS3-5: Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models

		could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [*Assessment Boundary: Assessment is limited to systems containing two objects.*]

7. **Background and Rationale:**

According to MS-PS3-2, students should be able to explain that as the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. Our lesson stems from the idea that students have difficulty completely and accurately explaining their understanding of modeling a phenomenon that occurs from objects interacting at different distances. To help students improve their modeling skills and educate them on the different energy transformations, we plan to have students work together to model and explain an energy change. Using the interactions of magnets and colliding objects, the students will test and observe the energy transformations. Following their experimentation, the groups of students will model the changes they observed to help provide an explanation. The following information lists previous and future learning expectations for students when discussing energy and its changes. Understanding what students will and should know about energy helps to provide reasoning for our lesson proposal.

- By the end of Grade 5:

Students are beginning to understand energy and force and are able to "describe how energy behaves" but not define what energy is. The idea is around the notion of fields, but fields shouldn't be introduced at this grade level. By the end of grade 5 the students should be able to predict the energy transfer when forces act between two objects. Students at this level will learn about the invisible forces they cannot see and should not be expected to use fields in their explanation. Students will use the term potential to describe stored energy.

- By the end of Grade 12:

Students should be able to connect changes in energy to forces acting between objects and calculate the magnitude of the forces. They will also connect potential energy changes to changes in forces and fields between objects at a distance. Finally it is expect that the students will connect energy released or absorbed in chemical reactions to changes in electric fields acting between particles.

These expectations were taken from the Framework for K-12 Science Education, available for download at https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concept

8. Research and Kyouzai kenkyuu

NGSS For All Students, from the NSTA press, focused on the *Framework* and NGSS to explain the vision of science for all students and promoting an approach to achieve this vision based on research on science learning. The research tells us that students learn science best when they deeply engage in the practices of science and engineering, over a long period of time, to develop coherent understandings of a set of disciplinary core ideas.

Our research for the lesson on teaching students how to model began with discussions on what making a model really meant. As a team, we began to look at common “modeling activities” teachers would use to explain how something functions and where they succeeded and fell short. We discovered that our previous experiences with models was actually more representative of creating a diorama. Models that we have students create need to explain what is happening and not just rely on a visual representation.

We used *Teaching Energy Across the Sciences,* from the NSTA press, to delve into energy with respect to magnets. We know that energy is necessary to apply a force. The notion of a “field” as an area to store or transfer potential energy is challenging for a student to understand. In elementary school, students begin to understand energy as a push or a pull, generally in direct contact with each other. They do not explicitly connect the scientific concept of force and energy yet.

In middle school, the notion of potential energy is introduced. Students should recognize that when two objects interact at a distance through magnetic forces, there is potential energy stored in the system. The potential energy is stored in the field and when the fields interact, the energy is transferred and a change in motion is observed. Students should begin to use language that allows them to think about energy in a more abstract manner than in elementary school. Stored energy from a distance between multiple objects is referred to as potential energy and energy of motion is kinetic energy. In *Disciplinary Core Ideas: Reshaping Teaching and Learning,* by the NSTA press, they explain that as students begin to discuss the idea of potential energy in middle school, they should start to recognize that some changes in the energy of systems are observed as changes in the arrangement of objects that exert forces on each other via fields. As they become more familiar with the idea of transfer, students will begin to earn linguistic shortcuts such as *flow*, after they have had sufficient practice and experiences.

In the *NGSS For All Students*, they stress the idea that a science practice-rich classroom should provide abundant language development opportunities for every student. Students are using their experiences with real-world phenomenon to learn new language. Their participation in classroom discourse supports learning to express ideas, thoughts, and questions effectively. This allows all students the opportunity to contribute to the shared development of ideas.

Starting at a young age we ask the question “why.” We are born curious about the way the world and things around us work. You could say we are born to be scientists and engineers. It is a curiosity that seems to get lost by most people as they age and they become accepting of the way things are often responding to children who ask them “why” with “That’s just the way it is.” This is the way many of us were taught science. We were often spoon fed facts and required to regurgitate them back to our teachers, rarely ask why we think a phenomenon exists or how could we explain it. Modeling is a way to bridge the gap between the just knowing basic facts and being able to use that information explain how something works.

Modeling is at the core of the intellectual work of scientist. It helps them organize and integrate theoretical and empirical work toward the goal of sense-making about phenomena (Schwarz, et. al. 2017). In order to be used as a reasoning tool, a model needs to be constructed for a sense-making purpose and it needs to be link to a phenomenon (Schwarz, et. al. 2017). We want students to be able to develop useful knowledge and become lifelong learners.

For modeling to be effective it is crucial that students are thinking about the model and what goes into it and why those things are important. “Having each class establish its own norms about modeling is much more effective than having the teacher tell them about the model, show them how to use it, and then have them use it.”(Schwarz, et. al., 2017, p. 118). In our unit of study, the students are creating their own models to explain that a system of objects may also contain stored (potential) energy, depending on their relative positions. One of the most challenging things about modeling for the teacher could be anticipating student thinking. It is difficult to anticipate student responses before they actually do the activity. What sequence of questions and experiences will propel students from their initial understanding the desired understanding? How will students respond to the questions and activities? What data will help students develop the model? How can we guide their thinking?

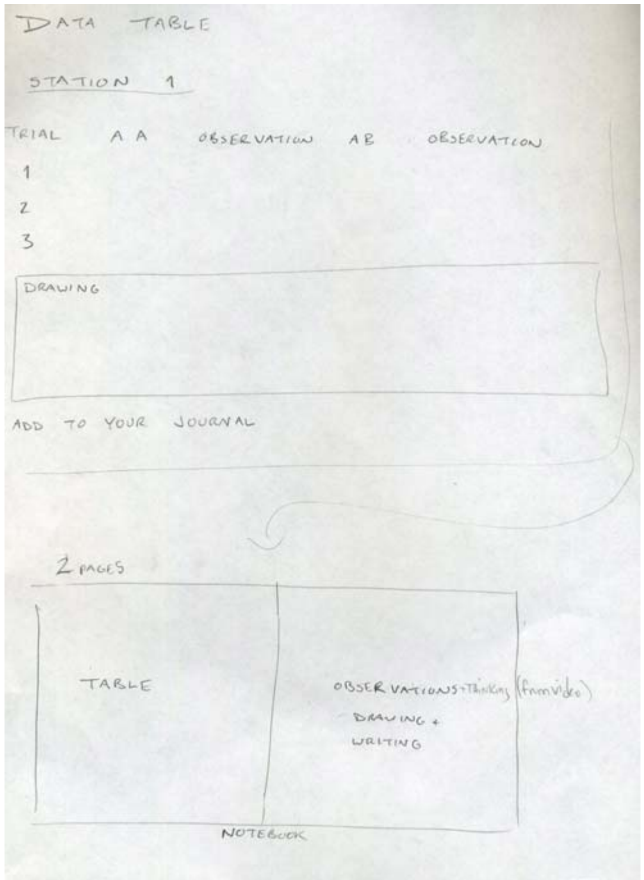
The “practice of modeling should involve students in developing a model that embodies aspects of a theory, and revising that model to better meet the goals of explaining and predicting” (Schwarz, et. al. , 2017, p.117,). Throughout this unit of study, students will develop and revise their models to better explain the phenomenon. An explanation is the ultimate use of a model.

In order for the students to develop a sufficient consensus model that will meet the learning expectations we have set for them, our team looked into methods of modeling and what modeling skills they need to develop. Giving our students a seemingly simple phenomenon to represent allows them to model with different levels of complexity. As students progress through different grade levels the complexity of their models will gain details on the transfer of energy from magnetism. By the end of their experimentation, we expect that the students will be able to model that the amount of energy transferred between a magnet and another object will increase or decrease with a change in distance. Learners will represent these changes in their models through a series of symbols and written statements that explains what they record in their notebooks. Through peer discourse, the students will be able to gain information from each other and make suggestions to change the model. The peer to peer interactions promotes a constructivist learning environment that challenges students to seek collaboration and challenge previous ideas. The *Nondestructive Testing Resource Center* states that learning is an active process and a student will learn the most trying to make sense of something on their own. Using a variety of stimuli in our lessons by encouraging students to experiment will allow more students to meet our learning goals.

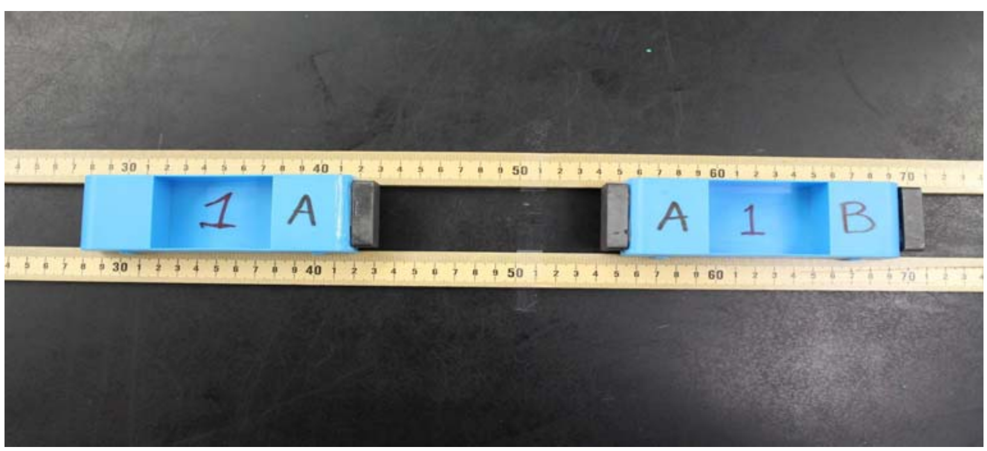
9. Unit Plan

Lesson	Learning Goals and tasks
1	**Introduce Phenomenon** Students will manipulate magnets of different qualities and paper clips on a string, while discussing with peers what they are experiencing. Students will create “I wonder statements” on sticky notes while experiencing the interactions between the paperclips and the magnets. Students will independently sketch and label their models to describe the phenomenon. “How can you develop a model to represent your thinking and understandings?”
2	**Exploration Day**

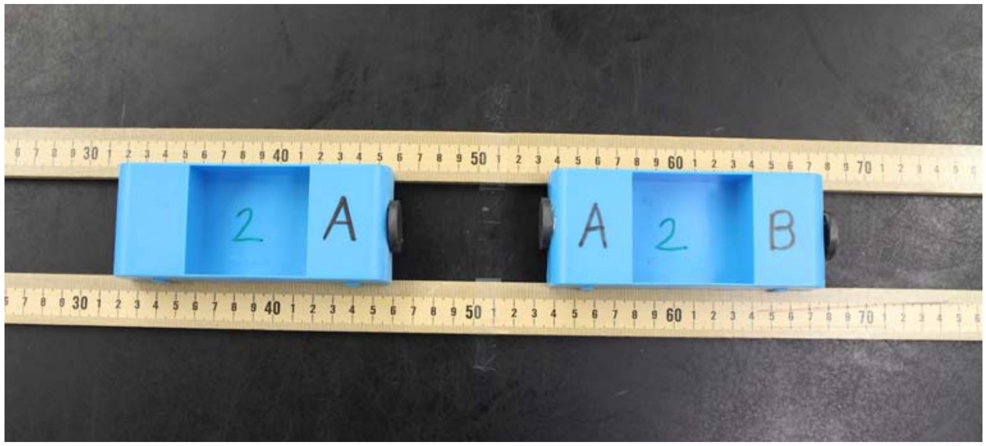
	Students will manipulate various magnets and materials and collect observations. Students will create “I wonder statements” on sticky notes while analyzing observations from the experimentation and place them on a “parking lot(wonder window)” Students will share and revise model plans with tablemates. “How might your explorations change your model?”
3	**<u>Further Investigations</u>** Students will suggest possible investigations to gather the data needed to complete the model. Students will make claims based on their current knowledge and collect as a class. By the end of day, students should be able to say, **“we need a data table that contains…”** (once the students articulate what they want in the data table, we can provide that data table for them). “What information do we need to collect to complete our models?”
4	**<u>Data Variables</u>** Students will assess the similarities and differences between the stations. Rows will report out to class. Tablemates will manipulate the station to see how the materials should be used to fill in the data table; what is working and what are the challenges/constraints for the station. Students will connect how the setups and data are going to provide answers to your wonderwall. “How can your stations be used to complete your data table?”
5	**<u>Station Experimentation</u>** Students will record data, observations, and record in, slow motion, the interactions at each station.


DATA TABLE
STATION 1
TRIAL A A OBSERVATION A B OBSERVATION
1
2
3
DRAWING
ADD TO YOUR JOURNAL
2 PAGES
TABLE
OBSERVATIONS+Thinking (from video)
DRAWING +
WRITING
NOTEBOOK

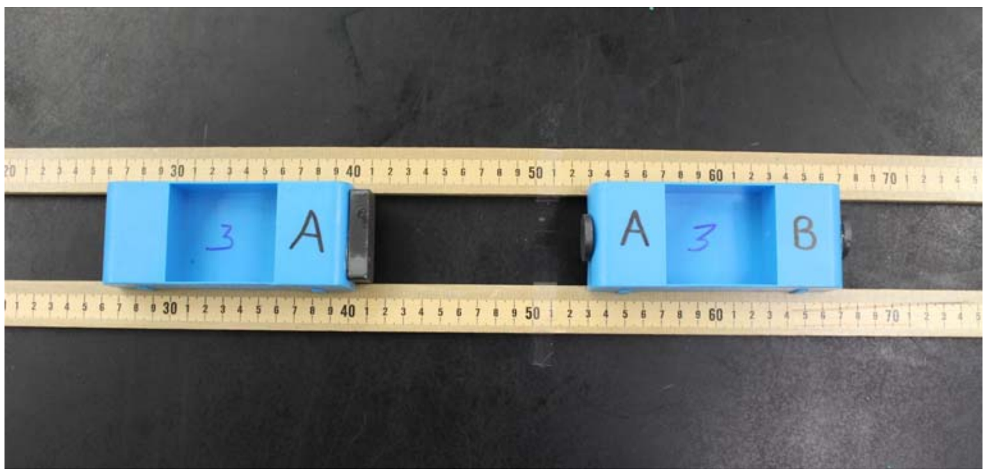
Station 1


1 A
A 1 B

Station 2



Station 3



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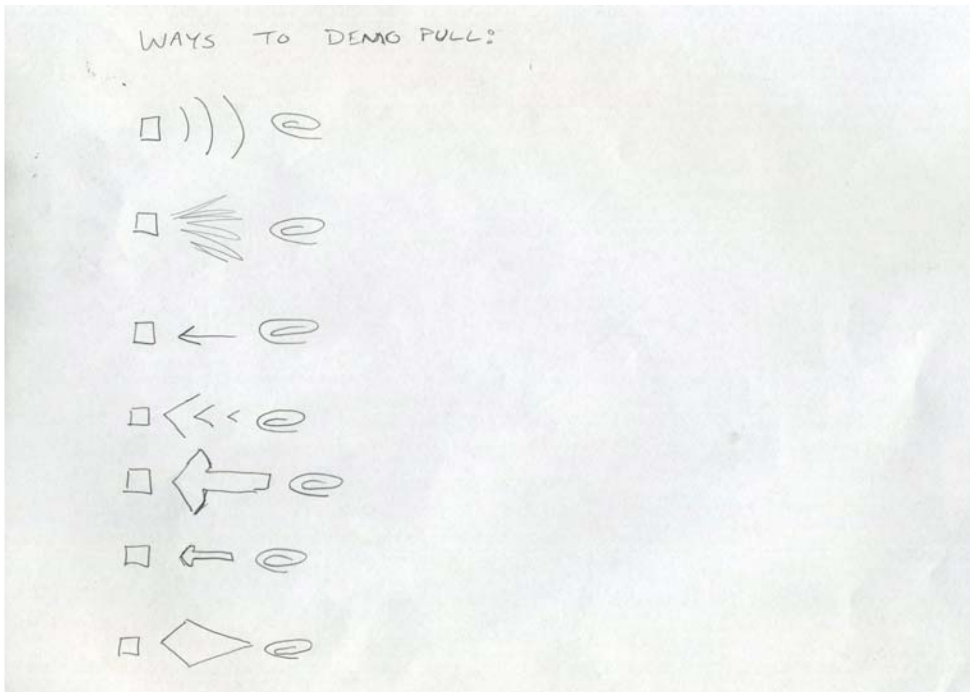
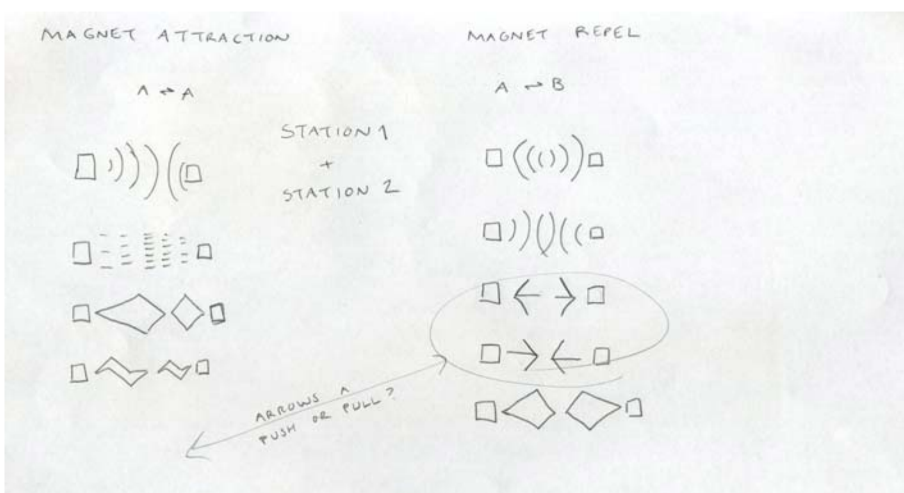
<u>Consensus Model (lesson study)</u>

Students come together to discuss their models and ask questions about the parts of the models. They should be referring back to their data and videos.

Develop a consensus model together as a group that can account for the cars AND for the original phenomenon.

In order to explain the phenomenon, each model must contain these components…





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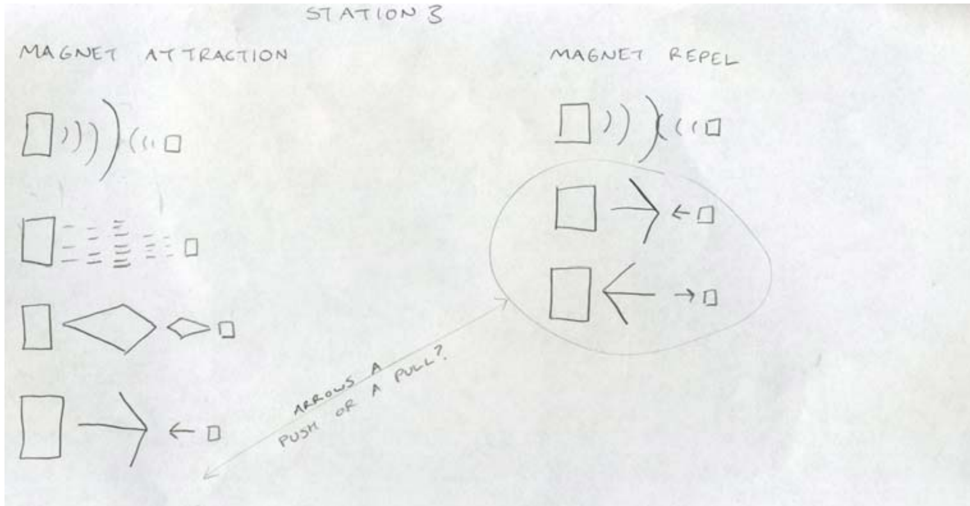
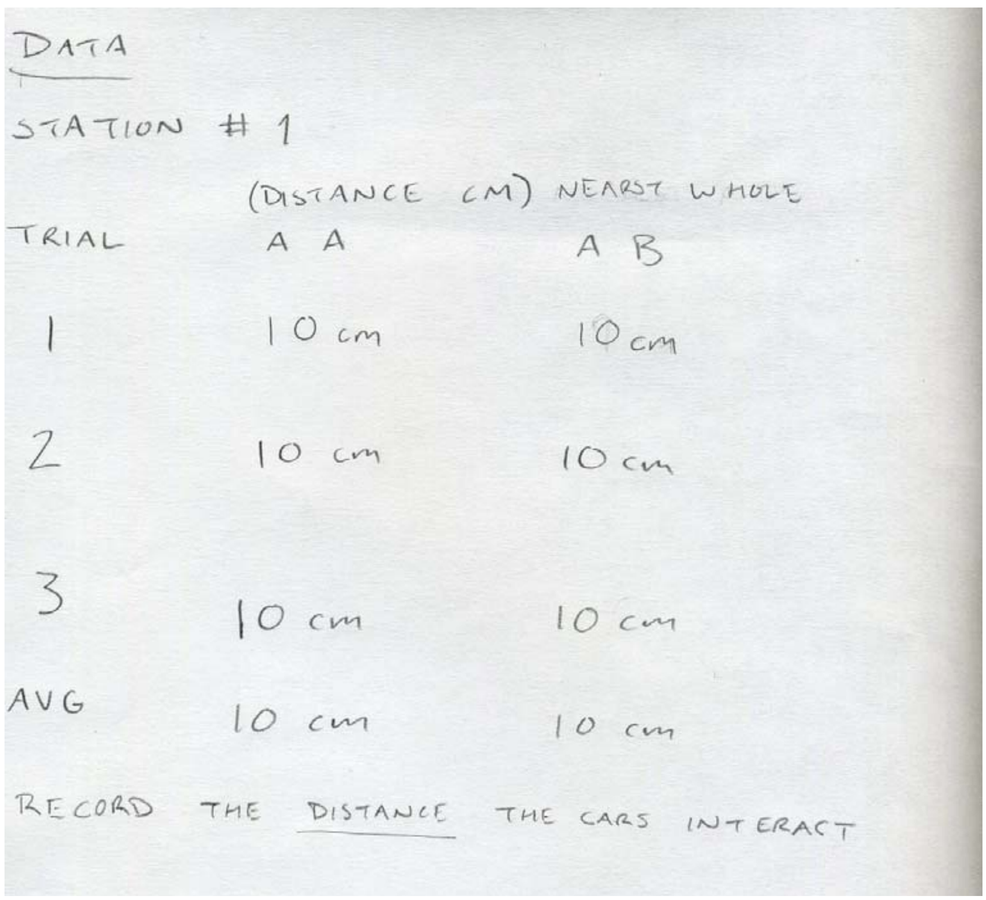


STATION 1



DATA

STATION # 1

(DISTANCE CM) NEARST WHOLE

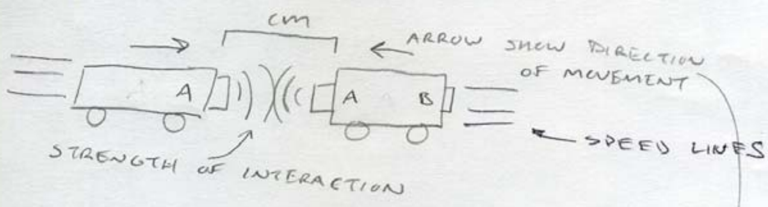
TRIAL	A A	A B
1	10 cm	10 cm
2	10 cm	10 cm
3	10 cm	10 cm
AVG	10 cm	10 cm

RECORD THE DISTANCE THE CARS INTERACT

OBSERVATION + MODEL (FROM VIDEO)

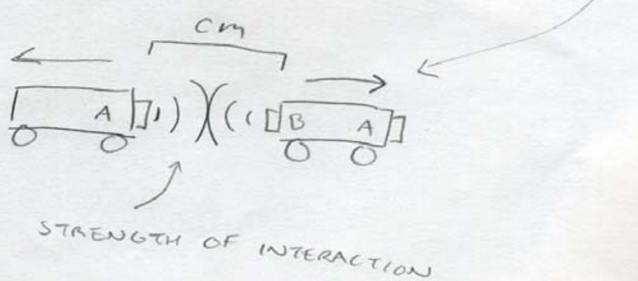
A A

- I KNOW IT INTERACTED B/C BOTH CARS MOVED BEFORE MEETING.
- THE CARS WENT FASTER/SPEED AS THEY GOT CLOSER TOGETHER.
- LOUD NOISE WHEN THEY MET



AB

- I KNOW CARS INTERACTED B/C A MOVED FROM B WHEN IT GOT CLOSER



STATION 2

DATA

STATION #2

(DISTANCE IN CM TO NEAREST 10TH)

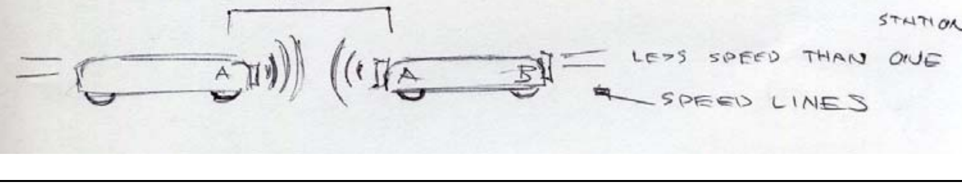
TRIAL	AA	AB
1	2	2
2		
3		

SAME AS ONE

II NOISE NOT AS LOUD

(# SAME MODEL AS ONE)

A MOVEMENT ARROWS TO SHOW SPEED
THESE ARROWS SHOULD INDICATE A SLOWER SPEED
THAN STATION ONE



STATION 3

DATA

STATION #3

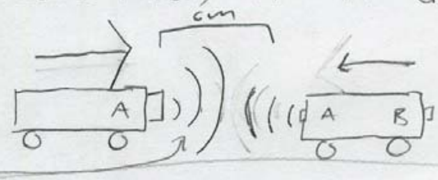
(DISTANCE IN NEAREST WHOLE CM)

TRIAL	AA	AB
1	5	6
2	6	6
3	5	6
AVG	5.5	6

OBSERVATION + MODEL (FROM VIDEO)

AA

- I KNOW THEY INTERACTED B/C BOTH CARS MOVED TOWARDS EACH OTHER
- A NOISE INDICATED INTERACTION
- CAR A ACCELERATED AS IT GOT CLOSER

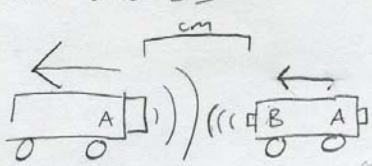


SIZE OF ARROW INDICATES DISTANCE CHANGE

SIZE OF LINES SHOWS DIFF, IN STRENGTH

AB

I KNOW THE CARS INTERACTED B/C THEY BOTH MOVED



10. Research Lesson Plan

Learning Objectives keyed to the NYS P-12 Science Learning Standards:

➢ *Learning Objective #1*				***Students will be able to work together to sketch and label a consensus model that describes the phenomenon.***
Standard	***DCI***	***SEP***	***CC***	***Statement from NYS P-12 Science Learning Standards***
MS-PS3-2				*Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.*
	PS3.C			***Relationship between energy and forces:*** *when two objects interact, each one exerts a force on the other than can cause energy to be transferred to or from the object.*
		1.1		***Develop and Using Models:*** *Modeling in 6-8 builds on K-5 and developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.* ● *Develop a model to describe unobservable mechanisms.*
			2.1 *3.1*	***Systems and system models:*** ● *Models can be used to represent systems and their interactions—such as inputs, processes, and outputs, and energy and matter flows within systems.* ***Energy and Matter:*** ● *Energy may take different forms (ex. Energy fields, thermal energy, energy of motion).*

Materials:

The following materials are required per station

- 2 Meter Sticks
- 2 Blue Cars
- 1 Table # card
- 1 Safety card

The following materials are required per group of 3-5 Students

- iPad with video recording (6 total)
- Paper for modeling
- Pencils

The following materials are required for the teacher's presentation and setup:

- 1 Neodymium
- 1 Large Rectangular Magnet
- 1 Small colored magnet
- Paper clips
- Twine
- Chart Paper Markers
- Chart Paper
- Projector/Monitor
- Masking Tape
- Scissors
- Kelly's Laptop
- Student science journals (previously collected on Friday, 11/2)

<u>Time-budgeted Procedure (45 minutes):</u>

Time (minutes)	***Activities***
2	***Class Introduction:*** *Students find seats, open their journals to their individual models, and review their models from previous lessons.*
10	***Peer Sharing:*** *Teacher explains working together to become acquainted with their new tablemates and share (and listen) their models, experiences, and thoughts from the last five lessons. Students may refer to the videos on Ipads from the previous lessons' investigations with magnets and cars.* *Questions to focus on during discussion:* *Do you see any similarities between your models?* *After sharing and listening, is there anything you would include in your model?*
10	***Class Discussion:*** *The idea of potential energy is introduced. Students will be prompted to discuss what they observed in terms of the different distances that the magnets interacted and how this relates to potential energy.* *Prompts:* *What are the differences in distance noticed when using different strength magnets?* *Where is the potential energy the greatest?* *How do we know when energy has been transferred between 2 objects?*
20	***Consensus Model:*** *Students will work together to construct a consensus model to explain how 2 objects interacting at a distance store and transfer energy.*
3	***Closure/Wrap up:*** *Students respond on index cards: How can you use your model to explain the interaction between two other objects in everyday life?*

11. Evaluation

12. Board Plan

Refer to images from Day 5 and 6 of the Unit Plan.