Lesson Title: Making Sense of Motion and Speed

Author: Joseph R. Blankenship

Topic:

- Defining motion as an object's position relative to a reference point over time
- Interpreting and describing the motion of an object using a distance/time graph
- Calculating an object's speed as distance over time
- Visually describing and compare/contrasting the motion of multiple objects by transferring gathered data to a graph and using evidence to pose and defend a scientific argument.

Targeted Grade Level: 6th Grade

Time Needed: *Approx.10-12 42-minute class periods.*

Subject Integration: Science, Math, Language Arts

Justification:

- **Science**: In these lessons, having covered the concepts of the particulate nature of matter (all physical objects are made of smaller particles called atoms and those atoms are constantly in motion) as well as kinetic and potential energy earlier in the year, students will begin their investigations into the study of linear motion. This is a natural progression as students, at this point, will understand the roles of energy and gravity in the movement of physical objects. That is the kinetic energy of an object changes when its speed changes and that potential energy is the energy of relative position between two interacting objects. Having experimented earlier in lab exercises involving the relative energy of different spheres dropped from various heights, and with such items as student built catapults, students will be ready to transfer the data they accrue from their observations to graphs in order to accurately describe trends they observe and use evidence to defend scientific arguments.

- **Math**: In these lessons, students will be able to practice representing and analyzing quantitative relationships between dependent and independent variables, further develop their understanding of statistical problem solving, as well as reason about and solve one-variable equations and inequalities..

- **Language Arts**: In these lessons, students will be required to read and follow multistep procedures, determine the meaning of key terms found in a scientific text, determine central ideas and provide accurate summaries to scientific texts using Lean Notes and other tools, integrate quantitative information expressed in words into a visual manner (graphs, etc.), and support claims with logical reasoning.

Standards: The Standards I will be using in this series of lessons are the Ohio Learning Standards for Science (adopted 2018). They are, specifically, the Physical Science standard, *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving*. Additionally, these lessons will address the following under the State of Ohio's Nature of Science standard of Scientific Inquiry, Practice and Application (see below):

- *Identify questions that can be answered through scientific investigations.*
- *Design and conduct scientific investigations using appropriate safety techniques.*
- *Use appropriate mathematics, tools and techniques to gather data and information.*
- *Analyze and interpret data.*
- *Develop descriptions, models, explanations and predictions*

Grade 6

INTRODUCTION TO CONTENT STATEMENTS

GRADE BAND THEME: ORDER AND ORGANIZATION

This theme focuses on helping students use scientific inquiry to discover patterns, trends, structures and relationships that may be inferred from simple principles. These principles are related to the properties or interactions within and between systems.

STRANDS

Strand Connections: All matter is made of small particles called atoms. The properties of matter are based on the order and organization of atoms and molecules. Cells, minerals, rocks and soil are all examples of matter.

EARTH AND SPACE SCIENCE (ESS)	PHYSICAL SCIENCE (PS)	LIFE SCIENCE (LS)
Topic: Rocks, Minerals and Soil This topic focuses on the study of rocks, minerals and soil, which make up the lithosphere. Classifying and identifying different types of rocks, minerals and soil can decode the past environment in which they formed.	**Topic: Matter and Motion** This topic focuses on the study of foundational concepts of the particulate nature of matter, linear motion, and kinetic and potential energy.	**Topic: Cellular to Multicellular** This topic focuses on the study of the basics of Modern Cell Theory. All organisms are composed of cells, which are the fundamental unit of life. Cells carry on the many processes that sustain life. All cells come from pre-existing cells.
CONDENSED CONTENT STATEMENTS		
6.ESS.1 Minerals have specific, quantifiable properties. **6.ESS.2** Igneous, metamorphic and sedimentary rocks have unique characteristics that can be used for identification and/or classification. **6.ESS.3** Igneous, metamorphic and sedimentary rocks form in different ways. **6.ESS.4** Soil is unconsolidated material that contains nutrient matter and weathered rock. **6.ESS.5** Rocks, mineral and soils have common and practical uses.	**6.PS.1** Matter is made up of small particles called atoms. **6.PS.2** Changes of state are explained by a model of matter composed of particles that are in motion. **6.PS.3** There are two categories of energy: kinetic and potential. **6.PS.4** An object's motion can be described by its speed and the direction in which it is moving.	**6.LS.1** Cells are the fundamental unit of life. **6.LS.2** All cells come from pre-existing cells. **6.LS.3** Cells carry on specific functions that sustain life. **6.LS.4** Living systems at all levels of organization demonstrate the complementary nature of structure and function.

NATURE OF SCIENCE GRADE 6-8

Nature of Science
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.

Categories	6-8
Scientific Inquiry, Practice and Applications All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.	• Apply knowledge of science content to real-world challenges. • Identify questions that can be answered through scientific investigations. • Design and conduct scientific investigations using appropriate safety techniques. • Use appropriate mathematics, tools and techniques to gather data and information. • Analyze and interpret data. • Develop descriptions, models, explanations and predictions. • Think critically and logically to connect evidence and explanations. • Recognize and analyze alternative explanations and predictions. • Communicate scientific procedures and explanations. • Design technological/engineering solutions.
Science is a Way of Knowing Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.	• Science is a way of knowing about the world around us based on evidence from experimentation and observations. • Science is a continual process and the body of scientific knowledge continues to grow and change. • Science assumes that objects and events occur in consistent patterns that are understandable through measurement and observation. • Science should carefully consider and evaluate all data including outliers. • Science is based on observable phenomena and empirical evidence. • Science disciplines share common rules for obtaining and evaluating empirical evidence.
Science is a Human Endeavor Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.	• Individuals from different social, cultural, and ethnic backgrounds work as scientists and engineers. • Scientists and engineers are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism and openness to ideas. • Scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination and creativity.
Scientific Knowledge is Open to Revision in Light of New Evidence Science is not static. Science is constantly changing as we acquire more knowledge.	• Science explanations are subject to revision and improvement in light of additional scientific evidence or new understanding of scientific evidence.

*Adapted from Appendix H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

Complete *Nature of Science* document is found on pages 8-12.

Ohio's Learning Standards for Science (begin page 125)

NGSS Performance Expectations

MS-PS3-1. *Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a whiffle ball versus a tennis ball.]*

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Developing and Using Models Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. • Develop a model to describe unobservable mechanisms. (MS-PS3-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS3-4) **Analyzing and Interpreting Data** Analyzing data in 6–8 builds on K–5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. • Construct and interpret graphical displays of data to identify linear and nonlinear relationships. (MS-PS3-1)	**PS3.A: Definitions of Energy** Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) **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. (MS-PS3-2)	**Scale, Proportion, and Quantity** Proportional relationships (e.g. speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-1),(MS-PS3-4)

Engaging in Argument from Evidence Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds. • Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5) - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-4),(MS-PS3-5)		

Common Core State Standards:

Math:

CCSS

MP.2	Reason abstractly and quantitatively. (MS-PS3-1),(MS-PS3-4),(MS-PS3-5)
6.RP.A.1	Understand the concept of ratio and use ratio language to describe a ratio relationship between two quantities. (MS-PS3-1),*(MS-PS3-5)*
6.RP.A.2	Understand the concept of a unit rate a/b associated with a ratio a:b with b ≠ 0, and use rate language in the context of a ratio relationship. *(MS-PS3-1)*

Ohio Learning Standards for Math:

Expressions and Equations
6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.

6.EE.7 Solve real-world and mathematical problems by writing and solving equations of the form x + p = q and px = q for cases in which p, q, and x are all nonnegative rational numbers.

6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.*

Statistics and Probability
6.SP.1 Develop statistical reasoning by using the GAISE model: a. Formulate Questions: Recognize and formulate a statistical question as one that anticipates variability and can be answered with quantitative data. For example, "How old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because of the variability in students' ages. (GAISE Model, step 1) b. Collect Data: Design and use a plan to collect appropriate data to answer a statistical question. (GAISE Model, step 2) c. Analyze Data: Select appropriate graphical methods and numerical measures to analyze data by displaying variability within a group, comparing individual to individual, and comparing individual to group. (GAISE Model, step 3) d. Interpret Results: Draw logical conclusions from the data based on the original question. (GAISE Model, step 4)

ELA:

CCSS:

ELA/Literacy -

RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. *(MS-PS3-1),(MS-PS3-5)*
RST.6-8.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks. *(MS-PS3-3)*,(MS-PS3-4)
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information

	expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-PS3-1)
WHST.6-8.1	Write arguments focused on discipline content. *(MS-PS3-5)*
WHST.6-8.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration. (MS-PS3-3),*(MS-PS3-4)*
SL.8.5	Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. *(MS-PS3-2)*

Ohio Learning Standards for English Language Arts (begin page 63):

Standards for Literacy in Science and Technical Subjects

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts

RST.6-8.2 Analyze content-area-specific text development.

a) Determine the central ideas or conclusions of a text.
b) Provide an accurate and objective summary that includes the central ideas or conclusions of the text.

RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks

RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

WHST.6-8.1 Write arguments focused on discipline specific content.

c) Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

Measurable Student Learning Objectives:

Motion:

- Learning Target 1: I can define and apply the terms, motion, speed, and distance.
- Learning Target 2: I can describe how an object in motion is moving.
- Learning Target 3: I can create and interpret graphs to describe the motion of an object.
- Learning Target 4: I can conduct experiments to determine how the position of an object changes over time.

Science Inquiry and Application:

- Learning Target 2: I can follow prewritten directions in lab activities in order to answer a scientific question
- Learning Target 4: I can use the correct math and science tools to gather information.
- Learning Target 5: I can analyze and interpret data.
- Learning Target 6: I can develop models, descriptions, explanations, and predictions to support findings in an investigation.

Nature of STEM: Under Ohio's Nature of Science standard of Scientific Inquiry, Practice and Application, students will engage in the following:

- Identify questions that can be answered through scientific investigations.
  - *The motion and speed of an object can be quantified and calculated.*
  - *The data derived from those calculations can be used graphically to infer evidence to support or dispute a scientific claim.*
- Design and conduct scientific investigations using appropriate safety techniques.
  - *Students will observe the motion of several chains of dominoes answering the question, "Does the amount of space between dominoes change the rate at which the chain of dominoes fall?"*
  - *Students will change one aspect of the catapult they built earlier in the year to determine if it will affect the speed in which a projectile travels.*

- Use appropriate mathematics, tools and techniques to gather data and information.

  - *Students will use standard units of measurement for distance and time when gathering information on the falling of domino chains and the flight of projectiles.*
  - *Students will calculate the speed of various objects using the equation, s=d/t*
- Analyze and interpret data.
  - *Students will transfer data gathered to appropriate distance/time graphs where their calculations will be interpreted as evidence in order to support or oppose a scientific claim.*
- Develop descriptions, models, explanations and predictions
  - *Students will use evidence in order to back up or revise claims made during scientific investigations.*

Engaging Context/Phenomena: There are two engaging phenomena that I am using for this series of lessons. First is the "Measure Your Reaction Time" game from NASA, in which students will review what they've learned in the previous unit on potential and kinetic energy as well as introduce the new concepts of both distance and time. The second Engage activity is the "Graphing Your Motion" game from Texas Instruments in which students use a calculator based ranger, overhead projector and a TI-84 graphing calculator to try and replicate various distance/time graphs using the motion of their bodies. Both of these activities will serve to expand students' knowledge of energy in moving objects as well as introduce the two factors required in order to calculate the speed of an object.

Data Integration: Students will be making use of the data supplied to them in the "Graphing Your Motion" game, in distance vs. time games found on the desmos.com website, and in interpreting the motion of an object over time in various worksheets. Students will also be gathering and interpreting their own data during the Speed Inquiry (domino) Lab and in their revisited Catapult Lab.

Differentiation of Instruction: There is much in the way of visual information, tactile engagement, and real world application in this series of lessons, with less attention paid to textbook learning. This will be an ideal situation for my ELL students who will be better able to describe the movement of an object using graphs and models than worrying about correct translation of difficult concepts from a textbook or article into their own language and then back during an assessment. Additionally, struggling students will be grouped together for labs, set up with extra small group instruction and clarification of concepts during independent worktime, and interventions during study hall (Note: our 6th grade study hall requires we provide interventions for struggling students). Finally, as struggling students will be grouped together, they will be responsible only for showing their understanding of core concepts.

Real-life Connection: The concepts of motion and speed lend themselves very easily to a number of real-world and cultural connections. The easiest connections, of course, with the middle school population I teach will be in the realm of sports. Everything from track and field games and NASCAR to velocity of a thrown football can lead back to this subject matter. For students not as interested in sports, activities with the dominoes and of course the medieval fantasy connection made with the catapults still lead to hands on fun and understanding.

Possible Misconceptions: Based on the 2010 version of the Ohio Standards for Science Learning, there are a few possible misconceptions students may have in working through these concepts: Of those, I've only found one that I feel may be a problem in my class. It is that "some students think that time can be measured without establishing the beginning of the interval." As we will be graphing the results of our experiments and all worksheets will indicate a time interval's beginning, I do not foresee a great deal of trouble with this.

Other misconceptions may include the idea that smaller objects may travel with more speed than larger, or that objects with more mass may always move slower.

Lesson Procedure:

Model	5E Objectives
Engage *Introduce the lesson with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.*	**Procedure:** *Students will enter and take a **Measure Your Reaction Time** worksheet, a **Claim, Evidence, Reasoning (CER)** guided notes worksheet from the cart and their **Science Notebook** from the shelf. Students will glue the border of the notes worksheet into the next available page of their Science Notebook for their bell work (approx. 2 min.).* *Once finished, students will get with their Curie partner and work to complete the Measure Your Reaction Time activity, using the materials furnished at the work tables and recording each other's reaction times in catching the meter stick on their white boards. During this section, Mr. B. will make his way around the room, checking for understanding regarding the activity and making sure everyone has their CER worksheet glued into their notebooks (approx. 15 min.).* *When time is called, Mr. B. will ask students, whole group, to share the results of their Reaction Time activity and ask what concepts from our last unit were brought to mind (gravitational potential and kinetic energy). After making sure everyone is on the same page and clarifying any lingering misunderstandings, Mr. B. will then ask students to talk with their partners (30 sec.) about any other concepts possibly at work in this activity, reminding them also to check the worksheet if necessary (distance, time, perhaps speed). Mr. B. will then point out the new "I Can" statements on the board (Motion Learning Targets 1-4) and take any questions regarding them or the Reaction Time activity (approx.8 min.)* *Mr. B. will facilitate a discussion about CER and its application in Science Class with the students, using a PowerPoint presentation. Students will discuss the definitions and purpose of CER using the example of which restaurant has the better fried chicken and which jelly bean sells the most every year. During this time, students will also be filling out their CER worksheet (approx. 15 min.).* *Homework: Students will conclude the exercise by creating a CER scenario of their own and filling out the back portion of their worksheet using the techniques practiced.* **Modifications** *Mr. B. will work with struggling and ELL student pairs during the Reaction Time*

	activity and provide partially completed CER worksheets. Mr. B. will also work to clear up any CER difficulties during intervention at study hall. **Standards Addressed** *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.* *Ohio Learning Standards for English Language Arts:* *RST.6-8.2: Analyze content-area-specific text development.* *a) Determine the central ideas or conclusions of a text.* **Formative/Summative Assessments:** *Quick one-on-ones with working pairs, whole group discussion, completed CER notes sheets.* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • *Claim, Evidence, Response notes worksheets* • *Copy of CER PowerPoint* • *Measure Your Reaction Time worksheets (Note: This activity will require whiteboards, dry erase markers, and a number of other materials listed in the description).*
Engage *Introduce the lesson*	**Procedure:** *Students will enter and take a* ***Reading Distance/Time Graphs practice packet*** *from the counter*

with an anchoring phenomenon. Facilitate student questions, discussion, etc. as appropriate. Learn about what students already know and want to know.	*and take out their CER homework from the night before. They will then, with a partner, attempt to answer the question on the board,* ***"How can you tell if something is in motion?"*** *During this Mr. B. will briefly check answers to homework (approx. 3 min.).* *When finished, Mr. B. will take a few students answers regarding the question on the board, looking for such ideas as distance, time, and reference points (although they will probably not use that term at this point). Mr. B. will then lead the students in the* ***Graphing Your Motion*** *activity. Mr. B. will choose volunteers to work the motion tracking apparatus on the Smart Board. Students will attempt to replicate premade motion graphs or create their own. Students will also try to "guide" other players to follow the correct patterns on the board by telling them to walk forward, backward, speed up and slow down (approx. 21 min.).* *Afterward, Mr. B. will ask students to discuss with their table groups two things regarding motion they* ***noticed*** *during the activity, and one thing they* ***wonder*** *about (approx. 1 min.). Mr. B. will take student answers, looking for such ideas as a horizontal line means standing still, a steep line means fast movement, or a line moving towards the y-axis means you are coming back to your starting point (approx. 8 min.)* *Students will then begin to work independently on the Reading Distance/Time Graphs Packet with the time remaining in class (approx. 10 min.). Mr. B. will work with struggling students during this time in small groups to check for understanding of core concepts. Any work on the packet not completed by students by the end of class will be considered homework.* **Modifications** *Mr. B. will work with struggling students in small groups during the Reading Distance/Time Graphs packet time.* **Standards Addressed** *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent*

	variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *Ohio Learning Standards for English Language Arts:* *RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks* *RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics* *RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).* **Formative/Summative Assessments:** *CER homework, board work question answers, observations/discussion during the Graphing Your Motion activity, Reading Distance/Time Graphs Packet.* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • *Graphing Your Motion instructions and materials required including TI-83 or 84 calculator and CBR 2 or Go! Motion and direct calculator cable.* • *Reading Distance/Time Graphs practice packet.*
Explore *Plan for students to engage in hands-on activities that are*	**Procedure:** *Students take their **Science Notebooks** from the shelf, take a **Measuring Motion** reading from the counter, and take out their Reading Distance/Time Graphs practice packet from the day before. Students will perform a **close read** and add any pertinent information to their **Lean Notes** pages in*

designed to facilitate conceptual change.	*their notebook. During this time, Mr. B. will check in with strugglers, then check for completeness and understanding of completed packets (approx. 12 min.).* *Students will then receive a **Visualizing Vocabulary** sheet to glue into their **Science Notebooks**. Students will write a sentence that demonstrates their knowledge of the terms, **Reference Point** and **Motion**. Students will then **create an illustration** of each term used in the real world (approx. 12 min.).* *After time is up, Mr. B. will ask for 2-3 student volunteers to share their sentences and drawings on the document camera. Students will then log into the **Desmos** website. After some brief instructions, they will play the **Polygraph Game** with their Carver partner. Mr. B. will stop the game from time to time to **comment on students' questions to each other** as they appear on the screen (approx.18 min.).* **Modifications:** *Mr. B. will work with strugglers to complete any unfinished Visualizing Vocabulary worksheets or lend ideas for any unfinished Lean Notes entries. Mr. B. will also answer deal with any difficulties in playing the Polygraph Game.* **Standards Addressed** *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.* *Ohio Learning Standards for English Language Arts:* *RST.6-8.2: Analyze content-area-specific text development.* *a) Determine the central ideas or conclusions of a text.*

	b) *Provide an accurate and objective summary that includes the central ideas or conclusions of the text.* *RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics* *RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).* **Formative/Summative Assessments:** *Lean Notes entries, Visualizing Vocabulary worksheets, class sharing and discussion.* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • *Measuring Motion reading* • *Visualizing Vocabulary worksheet* • *Create an account at www.teacher.desmos.com*
Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** *Students will enter and pick up a **Motion Graphs** formative from the counter. Based on their reading, lean notes, and time spent in the various activities over the past few days, students will complete the worksheet, determining what each d/t graph is displaying with regard to the motion of an object. Students will work individually on this assignment. When finished, students will bring their completed worksheets to Mr. B. for an instant score. Any score less than 4/5 will require students to try again. Mr. B. will work with strugglers who receive less than 4/5, but will not provide the answers. Once students receive their scores, Mr. B. will give them the **Motion Graphs 2** packet to work on. As the d/t graphs will be more difficult in this packet, students will be permitted to work with a partner. As time allows, Mr. B. will walk around the class checking for understanding and answering clarifying questions (approx. 30 min.).* *When time is called, Mr. B. will go over the answers for the Motion Graphs 2 packet, answer questions, and check for understanding (approx. 8 min.).*

	*Students will receive and take home the **Reading Distance/Time Graphs Practice 2** worksheet for homework (approx. 2 min.).* **Modifications:** *Mr. B. will work with struggling students individually on their Motion Graphs formative.* **Standards Addressed** *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.* *Ohio Learning Standards for English Language Arts:* *RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics* *RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).* **Formative/Summative Assessments:** *Motion Graphs formative (scored), Reading Distance/Time Graphs Practice 2 homework sheet.* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • *Motion Graphs formative* • *Motion Graphs 2 packet*

	• *Reading Distance/Time Graphs Practice 2 sheet*
Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** *Students will enter and pick up a new **Distance Time Graphs** worksheet for their bell work. They will also take out their **Reading Distance/Time Graphs Practice 2** homework sheet for Mr. B. to check. While students complete the new worksheet on their own, Mr. B. will go over any misunderstandings or mistakes with regard to the homework with strugglers and other students (approx. 10 min.).* *After time is called, Mr. B. will call on students to provide their answers to the bell work worksheet. The worksheet answers will be displayed as correct answers are given. Mr. B. will also take any clarifying questions and help with any misunderstandings (approx. 15 min.)* *Students will then receive the **Graphing Motion** packet in which the topic of calculating speed from known distance and time measurements is introduced. Students will complete the first page of the packet as a class together with Mr. B. Mr. B. will also take any questions at this time on how to calculate speed (approx. 7 min.).* *Students will work independently or with a partner to finish the packet with time remaining (approx. 10 min.).* **Modifications:** *Mr. B. will work with struggling students individually on their homework sheets from the previous night.* **Standards Addressed** *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the*

	relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. *Ohio Learning Standards for English Language Arts:* *RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).* **Formative/Summative Assessments:** *Reading Distance/Time Graphs Practice 2 homework sheet.* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • *Distance Time Graphs bell work worksheet* • *Graphing Motion packet*
Explain *Facilitate opportunities for students to explain their understanding of concepts and processes and make sense of new concepts.*	**Procedure:** *Students will enter and take out their **Graphing Motion** packets from the previous day. Students will work on the packet individually or with a partner until finished. During this time, Mr. B. will work with strugglers in small groups as needed (approx. 30 min.).* *Upon finishing, students will receive a **Speed Machines** worksheet, where they will practice calculating speed as distance over time (approx. 10 min.). Any portion of the worksheet not finished before the end of class will be considered homework.* **Modifications:** *Mr. B. will work with struggling students individually on their homework sheets from the previous night.* **Standards Addressed** *Ohio Learning Standards for Science:*

	6.PS.4: An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.9: Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.* *Ohio Learning Standards for English Language Arts:* *RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).* **Formative/Summative Assessments:** *Reading Distance/Time Graphs Practice 2 homework sheet.* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • *Graphing Motion packet* • *Speed Machines worksheet*
Elaborate (2.5 days) *Provide applications of concepts and opportunities to challenge and deep ideas; build on or extend understanding and skills.*	**Procedure:** *Students will enter and take a **Speed Inquiry** packet from the counter. They will also take out their **Speed Machines** worksheets from the previous day. Students and Mr. B. will go over the answers to the Speed Machines worksheet as a class, and Mr. B. will take any clarifying questions and work through any misunderstandings (approx. 8 min.).* *Mr. B. will then introduce the Speed Inquiry lab, discuss the procedure, review what good group work looks like, explain the CER conclusion at the end of the lab (reminding students of the PowerPoint and their guided notes), and divide students into groups* (NOTE: You may pick groups

	for your class or allow students to pick their own groups. I have done both. I would not recommend more than three to a group, however.) *(approx.10 min.).* *Students will gather all materials – dominoes, meter sticks, and painters' tape - and work until approx. 5 minutes before the end of class, at which time students will return all supplies debrief with Mr. B. (approx. 17 min.).* *Students will continue to work on this lab for the next two days.* **Modifications:** *Strugglers will NOT be grouped together this time, but Mr. B. will watch for good teamwork and participation. Mr. B. will then debrief with strugglers later during study hall interventions.* **Standards Addressed**: *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:* *6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.* *6.EE.7 Solve real-world and mathematical problems by writing and solving equations of the form x + p = q and px = q for cases in which p, q, and x are all nonnegative rational numbers.* *6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.* *6.SP.1 Develop statistical reasoning by using the GAISE model: a. Formulate Questions:*

	Recognize and formulate a statistical question as one that anticipates variability and can be answered with quantitative data. For example, "How old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because of the variability in students' ages. (GAISE Model, step 1) b. Collect Data: Design and use a plan to collect appropriate data to answer a statistical question. (GAISE Model, step 2) c. Analyze Data: Select appropriate graphical methods and numerical measures to analyze data by displaying variability within a group, comparing individual to individual, and comparing individual to group. (GAISE Model, step 3) d. Interpret Results: Draw logical conclusions from the data based on the original question. (GAISE Model, step 4) *Ohio Learning Standards for English Language Arts:* *RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks* *RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics* *RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).* *WHST.6-8.1 Write arguments focused on discipline specific content.* *c) Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.* **Formative/Summative Assessments:** *Completed lab packet* **Resources**: • *Lab packets* • *Lab materials, including lab group packs of 50 dominoes each, meter sticks, painters' tape.*
	Procedure:

Evaluate (3 days) *Assess students' knowledge, skills and abilities.*	*Students will enter and retrieve their **team catapults** built and used during the **Potential/Kinetic Energy** unit, and instructed to do the following.* • *Get with your catapult group members* • *Go to the hallway and gather data on the average speed of your projectile (dry beans) by firing your catapult 10 times.* • *Tabulate and graph your data and share with Mr. B.* • *Change **one** feature of your catapult (spoon, number of rubber bands, projectile) and repeat the procedure.* • *Compare your new data with data from the old catapult design.* • *Make a Claim, Evidence, Reasoning statement as to which catapult design is better along with any additional changes/improvements you may recommend for other teams to try.* *As this assignment will be their summative evaluation for the Motion and Speed unit, I am keeping the instructions vague intentionally. In this summative, I will be looking for the following:* • *Defining motion as an object's position relative to a reference point over time* • *Interpreting and describing the motion of an object using a distance/time graph* • *Calculating an object's speed as distance over time* • *Visually describing and compare/contrasting the motion of multiple objects by transferring gathered data to a graph and using evidence to pose and defend a scientific argument.* **Modifications**: Strugglers will again be gathered into teams. Mr. B. will assist with regard to gathering data, brainstorming on which change to make to the catapult, and good teamwork. Struggling students will be responsible for the end results, however, Mr. B. will be watching mostly for understanding of the core material. **Standards Addressed** *Ohio Learning Standards for Science:* *6.PS.4:* An *object's motion can be described by its speed and the direction in which it is moving* *Ohio Learning Standards for Math:*

	6.EE.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set. *6.EE.7 Solve real-world and mathematical problems by writing and solving equations of the form x + p = q and px = q for cases in which p, q, and x are all nonnegative rational numbers.* *6.EE.9 Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. For example, in a problem involving motion at constant speed, list and graph ordered pairs of distances and times, and write the equation d = 65t to represent the relationship between distance and time.* *6.SP.1 Develop statistical reasoning by using the GAISE model: a. Formulate Questions: Recognize and formulate a statistical question as one that anticipates variability and can be answered with quantitative data. For example, "How old am I?" is not a statistical question, but "How old are the students in my school?" is a statistical question because of the variability in students' ages. (GAISE Model, step 1) b. Collect Data: Design and use a plan to collect appropriate data to answer a statistical question. (GAISE Model, step 2) c. Analyze Data: Select appropriate graphical methods and numerical measures to analyze data by displaying variability within a group, comparing individual to individual, and comparing individual to group. (GAISE Model, step 3) d. Interpret Results: Draw logical conclusions from the data based on the original question. (GAISE Model, step 4)* *<u>Ohio Learning Standards for English Language Arts</u>:* *RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks* *RST.6-8.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics*

	RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). *WHST.6-8.1 Write arguments focused on discipline specific content.* *c) Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources* *WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.* **Formative/Summative Assessments**: *Completed summative* **Resources (Note - All printable resources will be included with the folder attached along with this post):** • Catapults • Building supplies, various projectiles (beans, pencil cap erasers, pom poms, etc.) • Graph paper • Meter sticks • Painters' tape

Teacher Background: *This is a physical science unit for 6th grade students. It assumes students' have a working knowledge of potential, gravitational potential, and kinetic energy, as well as thermal energy and the atomic nature of matter. All printable resources will be included with the folder attached to this unit. Websites for activities, labs, etc. are as follows:*

Catapult design (Note: This is not the exact catapult design I use, but it is acceptable. If you don't like this particular design there are a number of others to be found online.)

Dominoes These are the exact dominoes I use. They are excellent quality, inexpensive and will last forever.

Teacher.Desmos.com

TI-84 Graphing Your Motion game

NASA Measure Your Reaction Time activity