Climbing to the Mountain Top:
Measuring Motion in Middle School

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Brief Description of Group to be Taught: The Community Day Charter Public School is a relatively small (~300 students K-8) in the city of Lawrence, MA. This unit will be taught in the sixth grade to two classes of 20 students. Each group has 20% ELL students and 25% on IEPs. Both 6A and 6B have a close to even male/female ratio. Approximately 40% of students qualify for reduced price lunch.

Relationship of this Lesson to the unit: These five lessons will be situated towards the end of a start of the year unit on rock climbing. Within the larger unit, students will have previously studied topics in Earth Sciences (weathering, erosion, etc.) under the driving question *How can I become an expert climber* and the sub-question *What makes a good place to climb, and where can I find one?* At this stage in the unit, which is later in the year so as to coincide with the study of patterns and algebra in math, students will transition to the sub-question of *How can I measure my climbing?* Students will learn about force and motion, including distance, speed, and acceleration, within the context of scaling an indoor wall or a rock-face. Students will participate in a culminating activity involving a climbing field trip, during which students will measure each other's climbs applying the processes and concepts explored in the unit.

Massachusetts Frameworks Strand and Learning Standard: Included in the Understanding by Design Template Below

Title: _Go the Distance_____

Subject/Course: _Science_____ Topic: _Motion and Distance_____

Designer(s): _Bill Cummiskey _____ Grade: _6_____

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-S.P.11:** Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
- **MA-S.P.12:** Graph and interpret distance vs. time graphs for constant speed.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

Day 1:	Day 2:	Day 3:
• Motion is the change of position, relative to an arbitrary reference point, and is measured as distance. • Choose an arbitrary, but appropriate reference point. Note the position of an object before and after motion. • An increase in the force pushing an object will increase the distance it moves.	• Distance will vary, dependent upon the force applied (winds of a rubber band) to the object. • Isolate and control for variables that affect the subject being investigated.	• Graphs allow scientists to organize collected data and predict future events, based upon that data. • Choose and use appropriate type, scale, axis labels, and titles for graphing data.

Driving Question(s)

- How can I improve my rock-wall and out-door climbing?
  - How can I tell how far I need to climb and how fast I can climb it?

***Students will know*:**	***Students will be able to*:**
• Distance formula ($d= x_f - x_i$) and how to use it to calculate distance. • A reference point is "an arbitrary point on an object, used to establish position" (FOSS).	• Use appropriate standard metric units in measuring distance • Isolate and control variables of distance and number of winds.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will be able to graphically represent (scatter plot) data collected from the experiment and analyze the data (write a paragraph, answer verbal questions) to demonstrate understanding of <u>point of reference</u>, <u>distance</u>, <u>position</u> (<u>initial</u> and <u>final</u>). Students will be able to synthesize these ideas into a coherent written definition of <u>motion</u>, create an algorithm for calculating distance moved, and use algorithm in novel situations.

Key Criteria:

- Correctly labeled variables
- Coherent use of vocabulary
- Accurately plotted data on scatter plot graph

Other Evidence:

- Written homework assignments
  - Explaining daily activity
  - Journal Observations
- Word problems from math class (using distance formula $d= x_f - x_i$)

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ Two inch-square paste hooks, attached to the wall in 20m distance measurements.
- ❑ 6m of monofilament fishing line, high test strength
- ❑ 1x 5" propeller with rubber band
- ❑ 1x 11cm wooden rod
- ❑ 1x large (5x7) index card
- ❑ 1x 15cm plastic straw
- ❑ Strapping tape
- ❑ Meter sticks
- ❑ Meter tape (20m)
- ❑ Science notebooks
- ❑ 4x graphing handout
- ❑ Projector and transparencies

Learning Activities:

TIME	PROCEDURE	CONCEPT
1 day before: 2x15 min.	Group roles: to maximize time in class, each sixth grade group will take 15 minutes the day before the lessons to discuss group roles (4 person groups with a starter, recorder, reporter and getter).	Cooperative learning and group roles.
Day 1- 1:30 to 1:35	Do Now: In your own words, write 2-3 sentences explaining what *motion* is without using the word **move**.	Introducing the topic, seeking out misconceptions.
1:35 to 1:40/5	Share your answers within your group and come up with 1-3 sentences that include the best ideas from each person. *Recorders, make sure everyone is writing it down.*	Sharing, synthesizing ideas into coherent sentences.
1:40/5 to 1:50	Reporters present definitions, teacher writes the class' ideas on poster paper throughout, without supporting or rejecting thoughtful suggestions.	Creating background information.
1:50 to 2:10	Exploration: set up air-trolleys and explore motion. • Ask students if they know what a trolley is. Ask: *What makes a trolley different from a bus?* o Look for understanding that buses can change their routes.	

	This will set up later conversations about directionality and displacement.
	• Show a sample air-trolley and demonstrate how it moves. Explain that, for the next 10 minutes, groups will make their trolleys move and closely observe and note everything about that motion.
	• Have students think about:
	  o *(1) How are you going to get your trolley to move?*
	  ▪ *What can you tell me about its motion?*
	  o *(2) What evidence can you gather and record to prove that it moved?*
	  ▪ *What are you doing to make the trolley move?*
	  ▪ *How can you record that information in your journal?*
	  ▪ *What are you observing about the motion of the trolley?*
	  ▪ *How can that be recorded?*
	  o *(3) Can you make it move the same way every time?*
	  ▪ *Are you always doing the same thing, or are you adjusting the way you make the trolley move?*
	  ▪ *Are these adjustments important? Do they change the motion? Have you recorded them?*
	• Assign group spaces throughout the room for the air-trolley experiments.
	• Have getters gather materials while groups prepare chair spaces.
	• Check set-ups and allow groups to begin.
	• Circulate through the groups to ensure that groups are clear on directions and are working well.
	  o **Formative assessment checklist**
	  ▪ What is <u>motion</u>?
	  ▪ Need for <u>reference point</u>.
	  ▪ What is <u>distance</u>?
	  ▪ $d = x_f - x_i$
		Formative assessment questions

2:10 to 2:15	Stop the groups where they are. On a separate piece of poster paper, record the groups' answers to the questions:
	• *Did you get your trolley to move? How?*
	• *How do you know it moved?*
	  o *What evidence can you provide to the rest of us that **your** trolley moved?*
	• *Did you get it to move the same way every time?*
	  o *How did you get it to do that?*
	  o *If you didn't, what could we do in the future to **try** and get it to move consistently?*
		Providing evidence, thinking critically

2:15 to 2:25	Direct each group to find ways of providing evidence for the movement of their trolleys. Circulate amongst the groups with **formative assessment checklist**.	Providing evidence, thinking

	• Watch out for suggestions like "videotape it" or "I saw it move, it just did." • ASK: *How could you describe the movement of the trolley to someone who missed today's lesson?*	critically, collaborating to create meaning and understanding
2:25 to 2:30	Clean up. Make sure all the materials for the trolleys are returned to me by the getter. Have the recorder make sure that everyone has all the notes. Assign HW: Take home your **science journal** and tell someone about what we did today. Use your notes to remind you of the details of the exploration. Write down any questions they asked you, and the answers you gave them. Then, in a short paragraph, write 2-3 things that would have helped you in explaining the lesson. Make sure to include WHY it would have helped. All of this should be written in the next page of your notebook.	Care for materials. Writing and verbal communication skills. Including parents and the community.
Day 2- 1:30-1:35	Do Now: In your groups, share your experiences from last night. Combine your paragraphs into a bulleted list of what you wanted to know more about and what would have helped you answer the questions you were asked.	Synthesis of data, collaboration

1:35-1:45	• Have groups share their struggles and successes from the night before. Create poster board T chart.
	• Students descriptions should have included:
	  o The trolley started here (gesture) and ended there.
	  o The trolley went from point A to point B.
	  o Drawing a picture of the movement, with a before and after
	• Ask: *How far did your trolleys go?* if that hasn't been brought up yet. (Many parents will have asked their student.)
	  o On the whiteboard, using masking tape and an extra trolley, draw a model of the trolley and line (using a marker).
	  o Introduce the concept of a starting position (use suggestions from students) and the idea of "*x* marks the spot." Draw an *x* above the trolley.
	• Ask: *What should we look at next to see how far the trolley went?*
	  o Students will prompt me to:
	  ▪ Move the first trolley
	  ▪ Place a second one (go with this).
	  o Then they'll tell me to **measure** how far (may use <u>distance</u>).
	  ▪ Use "hands" first to measure the distance of the trolley
	  ▪ Students should tell me to use a ruler
	  ▪ Lead students to meter stick
	  • Important Concepts: metric system as scientific units, appropriate unit of measurement, need for system of measurement
		Collaboration
		
		Measurement (using appropriate units)

	• Call students up to measure how far the trolley has moved.
	  o Do this three times
	  o Poll class on which is best:
	  ▪ Should include front-back, back-back, back-front, zero-front, front-end.
	  ▪ Cross off all the ones that will give us incorrect measurements.
	• Ask: *How do we know which way it went*?
	  o Introduce <u>position</u>: where an object is at a certain point in time.
	  ▪ Follow up with <u>initial</u> and <u>final</u> position to determine direction.
	  o Introduce <u>point of reference</u>: a spot on an object that is used to measure how far it moved.
	• Discuss using x_i and x_f to find distance. Create distance formula.
	  o
		HoM 14

1:45-2:00	• Return to groups and set up the trolleys in the same places. New getters should collect materials, new starters should keep focus, etc.
	• Direct groups to measure **how far** their trolleys move. Have them note the positions (initial and final), reference point, and units of measurement. Instruct groups to write their observations in an organize manner.
	• Circulate among groups to help them organize their data in a chart.
	• **Formative assessment checklist**
	  o What is <u>motion</u>?
	  o Need for <u>reference point</u>.
	  o What is <u>distance</u>?
	  o $d = x_f - x_i$	

2:00-2:20	• Call a stop (~5-7 minutes in) and have groups share how they are organizing their data. As a class, develop an experiment that will help us measure how far the trolley is moving. Identify the variables at play (namely, how many winds of the rubber band AND distance) and assign specific number of winds to each group (10, *20*, <u>25</u>, 30, 35, <u>40</u>, *50*, 60) and have them record their findings. • Project a transparency for the data and have students (recorders) put their data on the board. • Disassemble trolleys and flight lines.	
2:20-2:28	• Distribute graphing worksheets to each group. Have each member rewrite the data from the board onto their worksheet. • As a class, discuss the nature of independent and dependent variables (should have covered already in previous lessons) and	This will probably go over time.

	decide upon which is which (x- # of winds, y- distance in cm). • Using an overhead transparency, begin a graph with the students. Then have each group continue to graph the data. • While circulating, introduce idea of <u>line of best fit</u> to students who are working at a faster pace. • Explain that the graphs will be finalized during math class the next morning.	
2:28-2:30	• Assign homework: In your **science journal**, write 3-5 descriptive observations of distance from your daily life. For example, describe the bus ride home as it relates to our class today. Make sure to include specific observations (measurements if possible) on final and initial positions, points of reference, and distance. Try to determine what the independent (number of winds) and dependent (distance in cm) variables would be in each case. This should take up at least half a page.	
Day 3 Prep	• Set up projector with laptop. Open excel. • Log on all four computers at the back for students to work on.	Technology Graphing Data
1:30-1:35	• Do Now: Come up with an experiment that you could do on the amount of dish fluid and cleanliness of your clothes. Which is the independent and which the dependent variables?	

1:35-1:50	• Introduce stations lesson:
	  o Ask: *How do scientists normally present data?*
	  ▪ Should get answers: in graphs, articles, to each other…
	  o Follow up on student that mentions graphs. Clarify *why* we use graphs (review from math class discussion).
	  o If not already discussed, mention that scientists use computer programs to help them organize and graph their data.
	  o Tell students that they will be creating their own graphs on the computers at the back of the room (in pairs).
	  o Demonstrate, with projector, the creation of a graph using alternate data.
	  ▪ Step 1- input data in two columns (Ask: *which is my independent variable column, which is my dependent?*)
	  ▪ Step 2- create a graph, choose scatter plot.
	  ▪ Step 3- Label axes and title the graph
	  o Students not at the computer will work in pairs to answer questions about their graphs (**Appendix C**). These questions will lead into the idea of speed and slope.	

1:50-2:10	• Group 1 at computers • Teachers circulating, switching between computers and tables. o Check to make sure students are inputting data correctly, and using the right type of graph.	

	o ASK *Why are the number of turns on this axis, and the distance on this axis*? o *What was the measurement of the initial position for all of the air-trolleys?* ▪ Answer is zero. ▪ *Did it have to be zero? What could have been zero instead?* • The chair, the knot in the line, etc. • Group 2 at tables working on questions with teacher assistance o Clarify the difference between dependent and independent variables if necessary. If not, prompt students to articulate the difference. (Dependent is changed as a result of the person-controlled independent variable's manipulation. o Check for appropriate scales. o Monitor answers to questions, and differentiate for students with special needs (ELL, etc.)	Differentiated instruction: use of graphic organizers when appropriate.
2:10-2:28	• Switch stations. • Repeat steps from above.	
2:28-2:30	• Clean up, save/print graphs, return to seats. • Direct students to finish write-up for H.W. • Hand in graph printouts.	

Appendix A:

Groupings

Group	A	B	C	D	E
Members	Liz	Emmy	Liyah	Jacky	Natalie
	Adolfo	Yeimi	Ivy	Eric	Angelidi
	Hannah	Jaxell	Kingdell	Patrick	Brian
	Eduardo	Adrian	Brandon	Alba	Jens

Group	A	B	C	D	E
Members	Marcus	Christina	Miguel	Na'Blage	Waleska
	Coraima	Grimilda	Dale	Margaret	Germaine
	Carolin	Elemy	Milton	Ashley P.	David
	Roberto	Ashley C.	Luis	Shakira	Gregory

Appendix B: Graph Worksheet

Air-Trolley Distance Graph

Graphing Your Data

Part 1. Gathering Data

1. What is the independent variable (x)? _____

2. What is the dependent variable (y)? _____

3. Input your data into the chart below (some x values have been filled in for you):

Run	‘x’ value (winds)	‘y’ value (cm)	Run	‘x’ value (winds)	‘y’ value (cm)
1	10 winds		1		
2	10 winds		2		
3	10 winds		3		
4	10 winds		4		
5	10 winds		5		
Run			Run		
1			1		
2			2		
3			3		
4			4		
5			5		
Run			Run		
1			1		
2			2		
3			3		
4			4		
5			5		
Run			Run		
1			1		
2			2		
3			3		
4			4		
5			5		
Run			Run		
1			1		
2			2		
3			3		
4			4		
5			5		

Part 2: Graph your data, using appropriate labels, title, scale and line of best fit.

Appendix C

What does it all mean?

Questions for Analyzing Graphs:

Part 1: Understanding Graphs

1. What is the scale of the x-axis? Each _____ boxes = _____

2. What is the scale of the y-axis? Each _____ boxes = _____

3. How did changing the number of winds affect the distance that the trolley went? Can you find a pattern in the numbers?

_____

_____

_____

_____

4. Did the trolley's distance change the way you would expect it to? How, or how not? How would you expect it to change? Why?

_____

_____

_____

_____

_____

_____

_____

5. What could we do next time to make the data line up more closely with our expectations (What variables could we control better)?

_____

_____

_____

_____

_____

_____

	Novice	Competent	Expert
Process Skill	Measuring from zero to the number, rather than from a random starting point. Struggles to name variables, or to explain why controlling them is important.	Controlling the same number of turns. Starts in the same place each time. Accurately measures position. Uses reasonable reference point. Can accurately name dependent and independent variables, and place them on the correct axes of a graph.	**Controls Other Variables:** Level string. Taut string. **Demonstrates Understanding of Measurement:** Demonstrates understanding of how to measure the exact position and reference point. Can articulate the relationship between independent and dependent variables.
Habit of Mind	Struggles with one or more roles. Needs prompting to contribute during group work. Students must be prompted to offer evidence for their claims.	Contributes to group work without prompting. Successfully fulfills each of the four roles. Students consistently offer evidence for their assertions.	Shows leadership skills in collaborative learning, while not being overbearing. Students provide hunches, and evidence for these ideas, that anticipate the direction of the lesson's content.
Concept	Has initial and final position, but doesn't see a need for reference point, or uses multiple reference points. Doesn't count the number of winds.	**Distance** To find distance, you have to note the starting position and final position. To be accurate, you need to have a reliable reference point. The number of winds will affect the distance the trolley travels.	The same number of winds should make the trolley go the same distance, all other things equal/controlled.

Title: _Lesson 2_____

Subject/Course: _Science_____ Topic: _Speed_____

Designer(s): _Bill Cummiskey _____ Grade: _6_____

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-S.P.11:** Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
- **MA-S.P.12:** Graph and interpret distance vs. time graphs for constant speed.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

Day 1:	Day 2:	Day 3:
• Speed measures how far something travels in a given amount of time. • Keeping variables constant is necessary for collecting reliable data.	• To create an algorithm for calculating time speed, we must have data on an object's motion for distance and time. • Observed data can be used to create general algorithms.	• Graphs allow scientists to organized collected data and predict future events, based upon that data. • Graphs of speed have distance and time as the x- and y-axes. • Choose and use appropriate type, scale, axis labels, and titles for graphing data.

Driving Question(s)

- How can I know how fast I'm climbing my route?

***Students will know*:**	***Students will be able to*:**
• $v=d/\Delta t$ • $d=v \cdot \Delta t$	• Collect data and graph line plots • Identify variables (dep, indep)

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will conduct experiments, self-designed, to collect data relating to speed. Students will then graph this data, determine an algorithm for finding average speed, and analyze this data and the experiments while answering questions in a lab write-up.

Key Criteria

- Speed and distance formulas
- Keep (and understand why) variables constant
- Keep units constant.

Other Evidence:

- Students are given incomplete descriptions of motion and asked to identify the missing factors, substitute estimates, and calculate speed.
- Students create graphs
- MCAS Questions
- Students create drawings, using initial and final position, to represent and calculate speed.

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (for groups of 4)

- ❑ Two inch-square paste hooks, attached to the wall in 20m distance measurements.
- ❑ 6m of monofilament fishing line
- ❑ 1x 5" propeller with rubber band
- ❑ 1x 11cm wooden rod
- ❑ 1x large index card
- ❑ 1x 15cm plastic straw
- ❑ Strapping tape
- ❑ Meter sticks
- ❑ Meter tape
- ❑ Science notebooks/journals
- ❑ Projector and transparencies
- ❑ Stop watch
- ❑ Poster Paper

Learning Activities:

TIME	PROCEDURE	CONCEPT
Day 1 Prep	• Gather all trolley materials • Devise methods for varying height of the initial position of the line the trolley is on.	
1:30-1:35	• Do Now: write the formula we created for calculating distance (*d*) and label all of the parts with a sentence or phrase describing what they are (e.g. *d* → distance: how far an object moves from one position to another). Above and beyond: Give an example for each of the parts (make sure that the examples all work well together). • Discuss the Do Now	
1:35-1:40	• KWL on board- Ask: *What variables were at work when we investigated distance using the trolleys?* o Look for: position (initial and final), point of reference, number of winds. • *What do we know about the trolleys that were wound up more?*	Identifying variables

	o *How does varying the number of winds affect our data*? o Students should answer that the more winds the further the trolley went. o Some students will say that the more it's wound, the **faster** the trolley would go. • *Do we KNOW if the trolley went faster with more winds?* o If YES: ask for evidence. o If NO: ask why not? What do we need? • Identify the need of <u>time</u> measures. <u>Time</u> will be our new variable. • *How can we measure time?* o Student answers should include: clock, watch, stop watch o Discuss which would prove EASIEST to use; stop watch because it starts at *t*=0, so less calculation is necessary. o Mention that seconds, minutes, hours, etc. are STI units	Measurement
1:40-1:45	• Break into groups and set up trolleys	
1:45-1:55 1:45-1:55 cont'd	• Direct groups to develop their own experiments for finding the speed of the trolley o Remind them of the importance of keeping track of ALL the variables and having only 1 dependent and 1 independent variable. • Circulate among groups to see how they are planning on obtaining data about TIME. o Groups should be using stopwatch from the start of their trolley motion until when it stops OR until it reaches a predetermined distance. o Questions to ask: *What if it doesn't reach the distance?* ▪ *What about measuring until it stops rather than to a certain distance?* o *How many winds are you going to use?* • Teacher carries checklist to see if students understand: o <u>Time</u> as an important <u>variable</u> o Keeping other variables constant (e.g. number of winds, qualities of the wire, level wire.)	
1:55-2:00	• Regroup and discuss the different plans of each group to measure time. • Goals: o Have each group recognize that the number of winds must be kept constant. o Have whole class agree to start time at release and stop it as the air-trolley stops. o Assign the same number of winds to each group. (Make sure to test each air-trolley personally to ensure that they will go similar distances on similar number of winds.) o Project a chart on the board to collect data.	
2:00-2:30	• Allow students to run experiments. Recorders write data on the	

2:25	board in real time. At the end of the class, each group will have recorded all other groups' data for future use. • Clean up materials, make sure that all students have the correct data, assign homework.	
HW	• Organize notes for today's lessons in your **science journal**. Compare your results today to those from the first experiment with distance. How did you improve your control of variables? If you see any changes, note them down and give any reason you can think of for the change.	HoM keeping good notes
Day 2 1:30-1:35	• Do Now: Share you reasons from last night's homework with your table members. • Share ideas with group. • I will circulate to see different responses.	Thinking scientifically; analyzing data; finding anomalies
1:35-1:50	• Set up work stations • Continue collecting data • Project last days data on board	

1:50-2:00	• Break to observe data projected on the board.
	• Ask: *Which trolleys are moving faster? Slower? How can we tell?*
	  o Students answers should include mention of <u>time</u> and the fact that distance was kept constant or SAME
	  ▪ "Blue group's went fastest because it went 50 cm in less time than any of ours."
	  ▪ "Red group's was the slowest because it took the longest to get to 50 cm."
	  ▪ "Blue's trolley had the greatest speed because it was able to travel the same distance in less time."
	• Ask: *Do we know HOW FAST the trolleys were traveling?*
	  o Students may say: YES, we know which one was fastest.
	  o *But does that tell us how fast it was going? Can we measure it or give it a number value?*	

2:00-2:20	• On the board, project the following sentences:
	  o A car traveled 100 km in 2 hours. What was its speed?
	  o A girl swam 75 m in 3 minutes. What was her speed?
	  o A bicycle traveled 60 km in 4 hours. What was its speed?A group walked 50 km in 10 hours. What was its speed?
	  o A bus traveled 369 km in 4.5 hours. What was its speed?
	• Ask: *What would be the clearest way to organize this data?*Look for the response of a chart.Project **Appendix A** on the board to help organize data.Agree upon v = <u>speed</u> (on poster paper)Generate algorithm: $v=d/\Delta t$ (on poster paper)
	• Finish filling in the chart that is being projected	

2:20-2:30	• Start HW problems on calculating speed, using algorithm.	
HW	• HW- Tomorrow you will be switching groups for the do now	

	period to share what your group has been a) doing successfully, b) struggling with c) not understanding at all :) In your **science journal**, write three columns, a, b and c, and brainstorm 3-5 things for each (at least, for a and b). Be prepared to share these with members from other groups.	
Day 3 1:30-1:40	• Do Now: MCAS questions (see **Appendix B**) Review answers. • Break students into sharing groups and have them compare brainstorms. Direct students to: *Take notes on anything that might help your group to improve the work you've been doing.* • Return to groups and share new suggestions.	

1:40-1:42	• Introduce Station Work
	  o Station 1-Students (10) work in pairs at computers to create charts and graphs of their data. Graphs must include titles, labels, and appropriate scales and variables.
	  o Station 2- Students (10) work individually and with the teacher to create a Lab Write-Up for their experiments.
	  o Write-Up should include: Question, Hypothesis, Materials and Procedures, Results and Data, Analysis, Conclusions
	  ▪ See **Appendix C**
	  o Field questions about the assignment	

1:42-2:00	• Station Work
	  o If a member of the group finishes early, direct them to this website.
	  o ASK (While students are working on writing their graphs): *Do you notice a pattern in the data points you are plotting* (looking for "they're going up")?
	  o If any student has drawn a line of best fit, ask them to explain to the group what they did, as well as why.
	  o ASK: *From your data, does it look like the trolley is going at the same speed the entire time?*
	  o *Where does it look like it's changing?*
	  o *Why might we want to draw a straight line, rather than a connect-the-dot line?* (answers should include something about simplifying the data).	

2:00-2:05	• Switch stations • Field Questions about what is next	
2:05-2:25	• Station Work o ASK:	
2:25-2:30	• Direct students to: *Print two copies of your graphs. Hand in one to me and use the other to answer the lab write-questions.*	
HW	• Finish lab write-up. Due in 2 days. • On your way home, or around your home, find an example of speed in your daily life. In your **science journal** draw a diagram or picture of the motion of an object, including all the necessary information for an outside observer to calculate, using our	

	algorithms, the distance moved, time interval elapsed, and average speed of the object.	

Appendix A:

Distance (d): $d = x_f - x_i$	Time Interval (Δt): $\Delta t = t_f - t_i$	Speed (*what should go here?*): What will our formula be?
100 km	2 h	

Appendix B:

Directions: Answer the Multiple Choice questions that follow. Be sure to show all your work.

Work:

Question 1: An airplane takes off from Boston for the 980 km trip to Detroit. The plane lands two hours later. Which of the following **best** describes the average speed and direction of the airplane's flight?

A. 325 km/h W

B. 490 km/h W

C. 980 km/h W

D. 1960 km/h W

Question 2:

The diagram below shows the path of a jet from Washington, D.C. to Dallas, TX.

The trip takes approximately 2 hours and covers approximately 1900 km. Which of the following **best** describes the speed and direction of the jet's flight?

A. 475 km/h southwest

B. 950 km/h southwest

C. 1900 km/h southwest

D. 3800 km/h southwest

Appendix C:

Scientific Writing

Speed Lab Write-Up

Directions: Complete each of the following sections **prior** *to writing your lab write-up in paragraph form. Remember to use your science journal as a reference for your thoughts throughout the experiment. You may answer questions on another page if you need more space.*

Part I- Main Ideas: Question(s) and Hypotheses

(1) What was the question we were trying to answer in this experiment?

_____

_____

_____

(2) What hypothesis did (you/your group/the class) develop to answer this question?

_____

_____

_____

Part II- Steps: Materials and Procedure

(3) List the materials used to complete the experiment:

_____

_____

_____

(4) ***Carefully*** describe the procedure (steps) you used to complete the experiment.

_____

_____

_____

_____

_____

_____

Part III- Evidence: Results and Data

(5) At the end of your write-up, attach copies of all your science journal data (charts, tables, lists, etc.) as well as the graphs you and your partner created on the computer.

Part IV- Thinking it Through: Analysis and Conclusions

(6) How well did your group control the variables involved in this experiment? What were they and how did you control them? If you had problems, what were they and how did you try to fix them? Were you successful?

_____

_____

_____

_____

_____

_____

(7) What can you conclude about the speed of the air-trolley compared to the number of winds?

_____

_____

_____

_____

_____

_____

(8) What is the relationship between speed, distance and time?

_____

_____

_____

_____

_____

_____

_____

_____

_____

Part V- Speed in Daily Life: Real-world application.

You and your friend decide to take your bikes on a tour of the local park and bird sanctuary. The park is a great ride, because it has lots of dirt trails with large roots to jump and wooden paths that ride over swamps, streams and even a small river. You and your friend leave from your garage at 10 in the morning and ride until around mid-day. When you get tired, you sit for a while and talk about the things you saw while eating a lunch you had packed. After about half an hour you get bored and decide to ride down to the movie theatres. This is only 1.5 miles away, and you can get there easily in 15 minutes. Once there, you lock up your bikes and watch the new Marvel movie, which lets out at 3:30. You ride home in 20 minutes, just in time for an afternoon snack and some wiffleball with the neighborhood kids.

(1) In this story, you are presented with three different motion segments (riding around the park, riding to the movies, riding home). Some information is there, but perhaps not all. Identify what you would need to know if you had to calculate the average speed of each of these parts of the day.

_____

_____

_____

_____

_____

(2) Now, estimate numbers, with appropriate units, for each of these parts, and calculate the average speed.

a.)_____

_____

_____

_____

b.)_____

_____

_____

_____

c.)_____

_____

_____

	Novice	Competent	Expert
Process Skill	Starts in the same place each time. Can differentiate between dependent and independent variables, and place them on the correct axes of a graph, but isn't sure which one is which all the time.	Accurately measure positions and times. Uses reasonable reference point. Uses time as independent and distance as dependent variable.	Can articulate the relationship between independent and dependent variables. Recognizes need for constant units.
Habit of Mind	Struggles with one or more roles. Needs prompting to contribute during group work. Students must be prompted to offer evidence for their claims.	Contributes to group work without prompting. Successfully fulfills each of the four roles. Students consistently offer evidence for their assertions. Occasionally identifies anomalies.	Shows leadership skills in collaborative learning, while not being overbearing. Students provide hunches, and evidence for these ideas, that anticipate the direction of the lesson's content. Identifies anomalies in the data, and can suggest causes.
Concept	Always uses reference points. Struggles using formula correctly.	**Speed** Uses distance concepts, while adding the variable of *time*, to find relative speed. Can accurately use algorithm to calculate speed from collected/given data.	Anticipates the relationship between the speed of an object and its slope on a graph. Can rework speed formula to solve for other variables (d, t).

Title: _Force and Motion Inquiry Science Lesson Plan_____

Subject/Course: _Science_____ Topic: _Comparing Speeds_____

Designer(s): _Bill Cummiskey _____ Grade: _6_____

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.P.11:** Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
- **MA-SC.P.12:** Graph and interpret distance vs. time graphs for constant speed.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

- Average speed is the total distance traveled by an object divided by the total time from start to finish (FOSS).
- Speeds can be compared when they are of the same units, using either numerical calculations or graphs.
- Graphs can be manipulated to allow for data to make comparisons or predictions.

Driving Question(s)

- How can I measure my rock-wall and out-door climbing?
    - Who's climbing faster?

***Students will know*:**	***Students will be able to*:**
• The slope of a linear equation is rise/run	• Find the slope of a line. • Manipulate a graph to compare speeds.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): After participating in a run-walk experiment, creating graphs with observed data, students will be able to manipulate graphic data to compare the speeds of two competitors and devise (write) scenarios resulting in a tie between competitors with different average speeds.

Key Criteria:

- Slope = average speed
- Slope is rise over run. (In math class, the teacher will have begun to discuss graphing function tables. At this point, slope will be an elementary concept. They should know that, if the x and y are changing in a constant pattern, the slope of the line will be straight.)
- Slope shows change.
- Keep units constant.

Other Evidence:

- Worksheets
- Walk/Run Tie Race
- Graph multiple objects in motion to compare speeds.
- MCAS Questions

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ Orange Cones
- ❑ Masking Tape
- ❑ 4x Calculators
- ❑ 2x Stop watch
- ❑ 4x Rulers
- ❑ Gym space
- ❑ Meter tape
- ❑ Science notebooks
- ❑ **4x Graphing handout**
- ❑ Projector and transparencies
- ❑ Computer with Excel
- ❑ Photocopies of **Appendices**

Learning Activities:

TIME	PROCEDURE	CONCEPT
Prep	Obtain gym time and set up two courses of 20m each. Have cones at each end, with lines marked in masking tape. Delineate one course from the other with tape.	Goal: Have students measure time and dist. and calculate speed.
Day 1 1:30-1:35	Do Now: **Appendix E**	

1:35-1:50	Propose collecting speed data on students walking and running.
	• Discuss how we've seen the air-trolley move and how we've taken measurements to determine distance, time intervals and speed.
	• Tell students that we're going to measure *ourselves* moving. Take ideas for how we could do so.
	  o These could include: Running, walking, skipping, running backwards, etc.
	  o Have class decide on 4 types of locomotion to be measured
	• Ask: *What variables do we need to consider when measuring our movement to find speed?*
	  o Listen for: time interval and distance
	• Ask: *Which variable should we hold constant?*	

3-5 min	• When they agree on distance, tell them that we've got a 20m-course set up in the gym.
	• Direct each group to prepare a procedure for taking measurements
	• On the board, come up with:
	  o 1. Order of groups (Who is on which course at which time)
	  o 2. Roles and order of group members (who walks, runs… and in what turn)
	  ▪ Ask: *How many times is each person going to move?*
	  ▪ Solicit: at least 3 trials. **Check for understanding in students who hadn't shown it in previous lessons.**
	  o 3. What the non-movers are doing (timing) and taking notes.
	  o 4. Calculate speeds (back in the room).
	• Review transparency of data sheets	

1:50-1:55	• Class moves to gym. • Getters get materials.	
1:55-2:25	• Gather data. • Circulate to make sure students are recording measurements in the correct spaces, with correct units, etc. • Have groups that finish early use calculators to find their speeds.	
2:25-2:30	• Return to class. • Getters replace materials. • Assign HW	
H.W.	• Finish calculating speeds for each student in your group. *Make sure to find their average speeds for each trial and the mean of all three trials.* Graph each group member on your grid.	
Day 2 Prep	• Set up the projector and laptop. • Load a graph from a team that successfully plotted their data.	Goal: have students find slope from a graph.
1:30-1:35	• Do Now: *According to the graph, which student moved at the greatest speed? Which student moved at the slowest speed? How would you compare the two lines that show these two students?* • Discuss: Look for understanding that **slope of the line shows speed- the steeper the line, the greater the speed.** o e.g. Brandon's line is faster because he went further than Alba in the same amount of time; Angelidi's was faster than Jaxell because she got to the finish line first…	
1:35-2:00 5 minutes	• Ask: *Now that we know which line shows the fastest student, and also how to compare lines to find relative speed, how can we use the graph to actually calculate the average speed?* • **ThinkPairShare**: Direct students to consider the question individually, pair up with the person next to them, then discuss with their group. • Ask reporters for answers.	

5 minutes
 	
10 minutes
	• Develop concept that <u>slope of a line graph (*m*) = Δy/Δx = rise/run</u>
	  o Project **Appendix B** and hand out copies.
	  o Explain that this is a chart and graph of a car running down a ramp. **Could substitute air-trolley instead.**
	• **Individual Work:** Have students identify each line with the corresponding row from the chart. Circulate and help where needed.
	• Ask: *Which lines shows the fastest car/air-trolley?*
	  o *How do you know it's the fastest?* **(similar answers as above)**
	  o *What is the speed of the fastest trolley? How can we use our ideas from before to help us find the speed?*
	  o Work with whole class to find the Δ distance and Δ time (most likely from start/origin to finish/end of the line).
	  o Check answers from graph with *v* shown in the chart.
	  o Write on the <u>vocabulary</u> poster board: <u>slope = Δy/Δx = rise/run</u>
	  o If y = distance and x = time, then slope = speed.
	  o Use slope = Δy/Δx to find the speed for the other lines.
	• Ask: *Were we right about which lines was fastest and slowest?*	

2:00-2:25
 	
2:05-2:10
 	
2:10-2:28
	• Propose Team Challenge: *I want each of your teams to get together and propose a method for having a race where the goal is not to have a first place, second place, etc. Instead, this race is to see if,* ***as a team****, you can find a way to have everyone finish the race at* ***the exact same time****. You must use the same course as last when we took our measurements, and all four of you have to race together (you can't go one at a time), but those are the only rules.*
	• Ask (and record on the whiteboard) for a summary of the directions. Call on as many different students as possible, ~4-8. Look for: a) Race where all 4 members tie, b) everyone on the same course at the same time, c) **evidence/reasoning** that the plan will work
	• Give each student 3-5 minutes to prepare their thoughts, then let them go at it.
	• Circulate the room. Look for students suggesting to:
	  o Graph the data and change the **start time** or **distance** so that the lines will **intersect** at 20m.
	  o Equations where students are setting one variable to be equal and solving for time or distance.
	  o Help students to do it one step at a time. Rather than equalizing all four data sets simultaneously, lead them to the idea that they can get two equal, and then work with the next one, etc.
	  o Give struggling groups a copy of **Appendix C** to help guide their thoughts. Also allow some struggling students to work in pairs on <u>this website.</u>	

Wrap-Up	• Tell students that the next day they will be running their races based upon whatever work they came up with today. Have them make sure that every team member has the same information, in case one of them is absent tomorrow. • Remind them not to share their information with other groups.	
HW	• Have each member take home their science notebook and create a chart, or other organizer, that shows the **slope** of each of the lines in their graphs. Compare that to the speed they calculated earlier, to see that they are approximately equal.	
Day 3 Prep	• Set up the courses as in day 1.	
1:30-1:35	• Do Now: *Get together with your groups and look over your plans one last time.* • Hand out **Appendix D** • Head over to the course	
1:35-1:45	• Have groups 1 and 4 attempt their race while groups 2 and 3 are in cafeteria (adjacent room) so they cannot see. • Have groups 2 and 3 work on **Appendix D** • Circulate among groups that are racing to help in any way. Have them do at least 2 trials, recording the results. • Have co-teacher in cafeteria monitoring and helping groups with **Appendix D.** • Switch	
1:45-1:55	• Repeat with opposite groups	
1:55-2:00	• Return to class. • Assign **Appendix D** as HW.	
2:00-2:15	• Have groups report on their plans and the results of their races.	

2:15-2:25	• Display **Appendix C** on the board.
	• Discuss various strategies for getting Molly and Eddy to end their race in a tie.
	  o Shortening distance for Eddy OR
	  o Starting Molly later than Eddy.
	• Get groups to share revised algorithms for scenarios where v and Δt or v and d are known and the other variable is solved for.
	• On <u>vocabulary poster board</u> write algorithms:
	  o $d=v \bullet \Delta t$
	  o $\Delta t=d/v$	

Wrap-Up	• Check for understanding • Clarify homework (**Appendix D**)	

Appendix A

Student Speed Graph

Graphing Your Data

Part 1. Gathering Data

4. What is the independent variable (x)? _____

5. What is the dependent variable (y)? _____

6. Input your data into the chart below:

Walker's Name	Δt_1 (s)	Δt_2 (s)	Δt_3 (s)	Δt_{AVG} (s)	Distance (m)

Runner's Name	Δt_1 (s)	Δt_2 (s)	Δt_3 (s)	Δt_{AVG} (s)	Distance (m)

_____ Name	Δt_1 (s)	Δt_2 (s)	Δt_3 (s)	Δt_{AVG} (s)	Distance (m)

_____ Name	Δt_1 (s)	Δt_2 (s)	Δt_3 (s)	Δt_{AVG} (s)	Distance (m)

7. Calculate the average time for each member and record it in column five (Δt_{AVG}).

8. Calculate the average speed for each member. Show your work

Part 2: Graph your data, using appropriate labels, title, and scale.

Appendix B

See transparency 11 (FOSS Force and Motion)

Appendix C

See Transparency 13 (FOSS Force and Motion)

Appendix D

See Transparency 14 (FOSS Force and Motion)

Appendix E

An escalator at a shopping mall is 10 m long and moves at a constant speed of 0.5 m/s. If José steps onto the escalator at the bottom while it is moving, how long will it take him to travel the 10 m?

A. 5 s

B. 10 s

C. 15 s

D. 20 s

	Novice	Competent	Expert
Process Skill	Can differentiate between dependent and independent variables, and place them on the correct axes of a graph.	Recognizes need for constant units. Identifies loose variables (uncontrolled variables) and tries to control them. Uses appropriate units consistently.	Can articulate the relationship between independent and dependent variables. Can identify and offer substantial suggestions for controlling loose variables.
Habit of Mind	Struggles with one or more roles. Needs prompting to contribute during group work. Must be prompted to offer evidence for their claims. Occasionally identifies anomalies.	Contributes to group work without prompting. Successfully fulfills each of the four roles. Consistently offers evidence for their assertions. Identifies anomalies in the data, and can suggest causes.	Shows leadership skills in collaborative learning, while not being overbearing. Provides hunches, and evidence for these ideas, that anticipate the direction of the lesson's content.
Concept	Can find slope from graphs, but struggles manipulating slopes (more concrete understanding of graphs and data). Confuses units.	Can use linear slopes of graphs to compare speeds. Can manipulate graphical data, along either axis, to make graphs model scenarios. Can calculate and compare speeds using raw data of distance, position, and time.	Can manipulate data algebraically, as well as on a graph.

Title: _Force and Motion Inquiry Science Lesson Plan_____

Subject/Course: _Science_____ Topic: _Displacement_____

Designer(s): _Bill Cummiskey _____ Grade: _6_____

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.P.11:** Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
- **MA-SC.P.12:** Graph and interpret distance vs. time graphs for constant speed.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

- Motion can include information about direction as well as distance (change of position), which is called displacement.
- Displacement, when graphed, appears as a change in slope.
- Slopes can be positive, negative or zero in the real world. An undefined slope has no real-world meaning.

Driving Question(s)

- How can I improve as a climber**?**
  - How will I plan out my route before I climb?

***Students will know*:**	***Students will be able to*:**
• Positive distance is 'going away' and negative distance is 'coming back.' • In a graph of distance over time, positive slopes are positive distances, and vice versa.	• Graph and interpret data of an object in motion, showing positive, negative, and zero-slope movement.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s): Students will graph data relating to an activity involving recording displacement from a starting position, and answer questions relating to their motion.

Key Criteria:

- Students demonstrate that they understand the difference between (and can differentiate [label]) position and distance.
- Students know (include in written/oral responses) that change in position with the inclusion of direction is referred to as <u>displacement</u>.

Other Evidence:

- Students will respond, orally and in writing, to various scenarios depicting the motion of a rock climber.
- Student created graphs.
- Questions analyzing explorations.
- Students will draw diagrams of displacement and change in motion.

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ Poster paper.
- ❑ Photocopies of **appendix A**.
- ❑ Do Now Handouts.
- ❑ Multi-color transparency markers (at least 3).
- ❑ Transparency grid.
- ❑ Graph paper.
- ❑ Orange Cones
- ❑ Masking Tape
- ❑ 4x Calculators
- ❑ 2x Stop watch
- ❑ 4x Rulers
- ❑ Gym space
- ❑ Meter tape
- ❑ Science notebooks
- ❑ Two inch-square paste hooks, attached to the wall in 20m distance measurements.
- ❑ Air-trolleys
- ❑ Mono-filament line

Learning Activities:

TIME	PROCEDURE	CONCEPT
Prep	Photocopy **appendix A**	
Day 1 1:30-1:40	Do Now: Three rock climbers take their places on a wall. Each is underneath identical routes, with identical holds. On go, the climbers take off up the wall. Lila works slowly and methodically, checking her feet placement and handholds as she goes up. However, she is always moving, even if sometimes she needs to go a little slower to get her feet just right. Sam starts up the wall straight away as well. He obviously wants to get their first, because he is pushing hard and fast. This means, however, that sometimes Sam gets stuck in bad positions and has to backtrack to an earlier point. Kris, on the other hand, waits at the bottom for a few seconds before beginning to climb. When ready, Kris makes good time and seems confident about which are the best holds. Every now and then, Kris pauses to take a break and look to see what's coming next. After a while, though, it's back to business. Whenever Kris is moving, the pace is quick, but there are periods of rest in between.	Writing skills. Developing mental pictures. Artistic, visual, linguistic intelligences.

	Say: *In your journals, draw a picture of what these three climbers look like from* ***start*** *to* ***finish*** *of their climbs. Don't worry too much about making the holds identical. You can even use stick figures or position markers if necessary. When you've finished your drawing, predict who will get to the top first, second and last. Make sure to explain why, in 2-3 sentences.* • Have those that finish early draw theirs on poster paper in the back.	
1:40-1:45	**TPS**: Have students share their drawings and predictions in pairs.	Collaborative learning, ensuring comfort with answers.

1:45-1:55
 	
1:55-2:10
	Sharing and Graphing:
	• Post the pre-drawn pictures around the class
	• Ask: *Who can identify this picture that* ***Yeimi*** *drew?* (repeat for each poster). Make sure that students are giving evidence for their choices.
	• Ask: *What new information have we added in this situation that was not present when we talked about the motion of our air trolleys or our races?*
	    o Look for answers including:
	        ▪ People at rest, not moving, a stop
	        ▪ Downward movement, going backwards, etc.
	• Introduce the idea that we're going to try to graph the motion of these three climbers.
	• Ask: *What are my dependent and independent variables going to be?*
	    o Introduce the idea of using <u>position</u> rather than <u>distance</u> as the dependent variable.
	• *What should my scale be?*
	    o Students require additional information at this point. Generate a ruler on the side of each drawing that is to scale, or have already placed this on the poster board that the students drew on. Have the class estimate the time to scale that wall (~**90-120** seconds) and randomly assign finishing times to each climber based upon the predictions from the previous discussion.
	• Project a graph of distance vs. time. Hand out personal graph sheets as well, or have students use their own graph paper.
	• Ask: *Who can come up and graph Lila's motion as she moved to the top?*
	    o This will be a linear graph.
	    o Have students calculate her speed.
	• Ask: *How about Kris. How can we graph* ***her*** <u>*ascent*</u>*?*
	    o **Teaching moment:** Perhaps someone will protest that Kris was a boy. If so, have a brief conversation about the
		Graphing data.
		
		Controlling variables
		
		Using speed algorithms to spiral knowledge.
		
		Intro vocabulary [<u>ascent</u>]
		
		Teaching equity.
		
		Wait time.

	important of not assuming gender roles. o Students should respond that, at the beginning, Kris' line didn't go anywhere. Let them struggle with this in pairs if necessary. Make sure to include WAIT TIME!!! Give students the info that Kris waited 5 seconds. o Personally graph the first few seconds of Kris' climb as a horizontal line superimposed upon the x-axis. o Ask formative assessment questions to make sure students understand: ▪ *Why is the line horizontal/flat?* ▪ *Where is Kris after one second? Two? Five? What does that mean?* o Continue to graph Kris' progress up the slope in intervals of stopping and starting. o Ask (to those unsure before): *So what does it mean if a distance vs. time graph has a horizontal/flat part to it?* o Ask: *How many 'parts' does this graph have?* (Answers depend upon how many were created during the exercise). • Ask: *Now how are we going to graph Sam? Let's say that, at first, Sam climbed [insert a reasonable distance, perhaps 10-20% of the wall in a brief period, ~5 seconds].* Take another volunteer to graph this while the class calculates Sam's initial speed. • Ask: *But what happened next?* o Students should respond that Sam went down. o Ask: *So, lets say Sam only went back 2 feet, and it only took him 5 seconds. Where would he be at t=5, 6, 7, 8?* o Students may need time to **TPS** this. • **Note:** Make sure the climbers end when we said they would	<u>Legs: parts of a motion graph that is more complicated than average speed.</u> Displacement (not yet as <u>vocab</u>)
2:10-2:20	On your own, look at **appendix A** and draw a picture of either someone walking or climbing the data of those motions. • Teacher circulates for formative assessment	Formative assessment
2:20-2:28	Share with your groups. Decide which were the correct drawings and why. • Teacher circulates for formative assessment.	
2:28-2:30	H.W. Pick three of three of the graphs that we used for our drawings and write one paragraph (1/3 to 1/2 page each) describing a climbing scenario (story) that fits your graph.	Reinforce interpreting position vs. time graphs.
Day 2 Prep	Set up 2 Trolleys across the back of the room.	
1:30-1:35	Do Now: Share one of your stories (the one you're least sure of) with the person sitting across from you. See if that person agrees with your story. If you chose the same story, how are they the same, different? Does it make a big difference, a small one, or none at all? • Discuss 1-3 of the graphs as a large group. Note the similarities and differences in the stories. Ask: *Why do these three stories*	HoM 10: Different explanations for same evidence.

	have x, y, and z in common? • Collect H.W. afterwards	

1:35-1:45	Whole group discussion:
	• Say: *Let's take a look at the second graph. We are going to graph the same information, but change the y-axis from 'position' to 'distance.' In pairs (the person sitting next to you, or opposite. Should have ensured that pairs include a higher student if with a struggling student, when necessary), graph the same information with the new axis.*
	• ASK: *What do we need to keep the same about the graphs before we can be sure we're graphing the same information?*
	  o Students should answer: keep the graph's the same **size** or introduce values and scales to the graph given and then make sure that those scales are the same on their graph.
	• *See what you get.*
	  o Circulate to make sure that students are working out that distance continues to increase on the y-axis as time increases, even though position might decrease (slope is always zero or positive).
	  o ASK: *Where does the graph of position vs. time start (origin)? Where is the first change in the graph (find specific point value)? Where is the next?… What differences do you notice between the two graphs?*
	• Once most students have it, project graph 2 and a blank graph below it. Proceed to graph the same information on newly labeled axes on a separate part of the overhead. Show students that, while position can increase **and decrease** along the y-axis, changes in distance are always positive.
		Begin an exploration into graphing displacement vs. distance.
		
		Controlling variables and understanding graphing (scales).

1:45-1:55	Introduce exploration: • Say: *Today we are going to do a variety of activities. Your group will be challenged to take graphical data and make your trolley move that way. You will also move your trolley, including stops, starts, and changes of direction, and then graph that information.* • *At first, you will see a graph of the air-trolley's movement. You will be responsible for trying to **make** the air-trolley move along the line in the same way.* See **Appendix B** for directions • *Then, instead of getting a graph and reproducing its motion, you are going to move your trolley and record its changes in position. Then you will graph this movement.* See **Appendix B** for directions. • Explain that we will likely only get through Part I today.	Interpreting Data, making changes to assumptions, depending upon data given (HoM 1).
1:55-2:00	Set up AT	
2:00-2:25	• Start Part I of the exploration. • Monitor student progress. • ASK: *Have you read all the directions yet? How are you doing on*	

	part one?
	• *Let's try to make it move. How are we going to do it?*
	  o *Now that we made a try, what do we need to do?* (Write down our methods in our notebooks).
	• *What worked, and what needs to be changed, to get the air-trolley to move the correct way?*
	  o *Do you think we should try a different method of* ***pushing?***
	  o Students should come up with the idea that moving the trolley by hand would be easier. Let them do this.
	• Circulate to all groups, facilitating discussions and the exercises.	

2:25-2:30	• Take down the AT's and get seated. • Assign H.W.: Write brief notes for questions 2 and 3 from part I in your science journals, so that tomorrow, your group can compare notes.	
Day 3 1:30-1:35	• Do Now: Set up air-trolleys and get started right away.	
1:35-2:15	• Allow students to finish part 1 and start on part II. • For Part II, ASK: *How do you want your trolley to move? How many legs do you have (if more than 3, suggest starting with three and adding more later)? How will you move the trolley to match them?* • For students in the competent to expert stage, ASK: *How the trolley will have to move if the lines of each legs are going to be straight (constant slope)?*	Formative ass't for expert.
2:15-2:20 2:20-2:28	• Disassemble trolleys and return to table groups. • Start working on graphs and answering questions.	Graphing data. Collaborative work.
H.W.	• Due in three days: *Using your notes and graphs, write your answers for parts I and II on a separate piece of paper. Hand these in, along with your graphs.*	

Appendix A

See transparency 16 (FOSS Force and Motion)

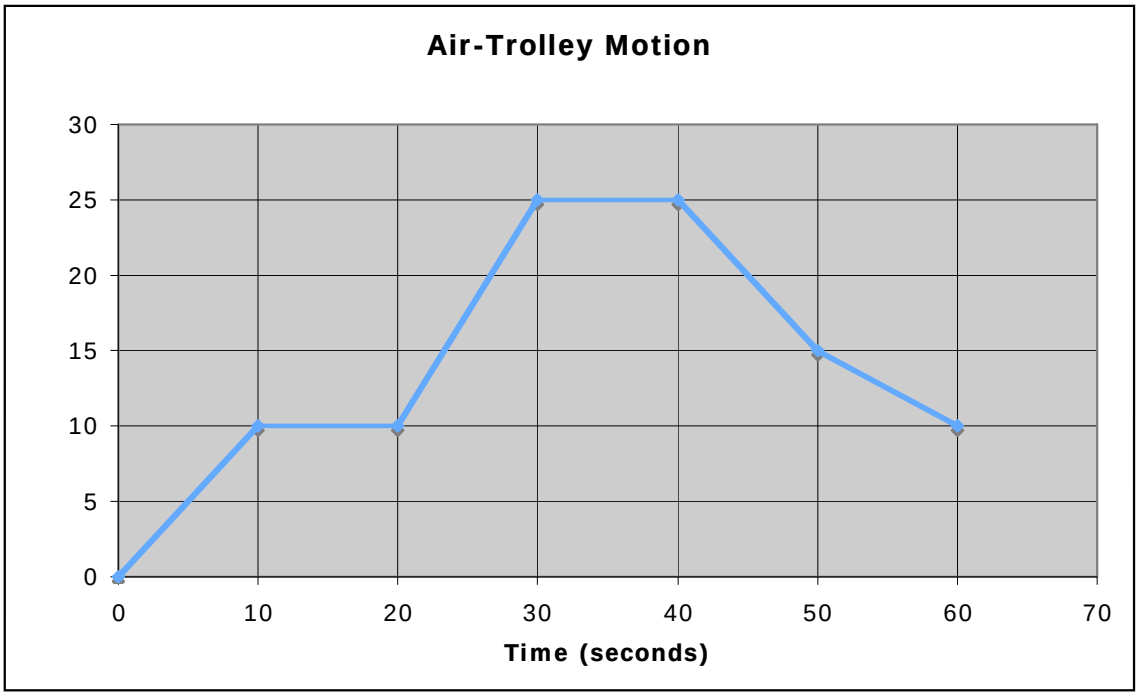
Appendix B

Part I. Recreating Motion from a Graph

Directions: Using the graph below, as a group, make your air-trolley move in the way described by the graph. Make sure that you discuss ***first*** *how you are going to reproduce each section of the graph. Write down your ideas before you begin.*

Take note that there are times connected with the position of the air-trolley. At first, ignore the time and see if you can get it to go the correct distance in the right direction. Once you get it to change its position correctly, try to add back in the timing. You will have a stopwatch to do this.

Answer the questions that follow in your science journal.



1) On the graph, label each section (these are called legs, make sure to add that into your science journal as a vocabulary term!) A, B, C, etc. Also label each point with a number, 1 (origin), 2, 3, etc. In your science journal, explain what is happening at each leg, and where each point is. Each leg should have at least 1-2 sentences of explanation.

2) What difficulties did your group encounter when trying to make the air-trolley move this way? How did you overcome these problems (what did you do to make it move)?

3) Do you think this graph makes sense? Does it represent the way an air-trolley *really* moves, or not? Explain why or why not.

Part II. Graphing Motion from Real-life Data

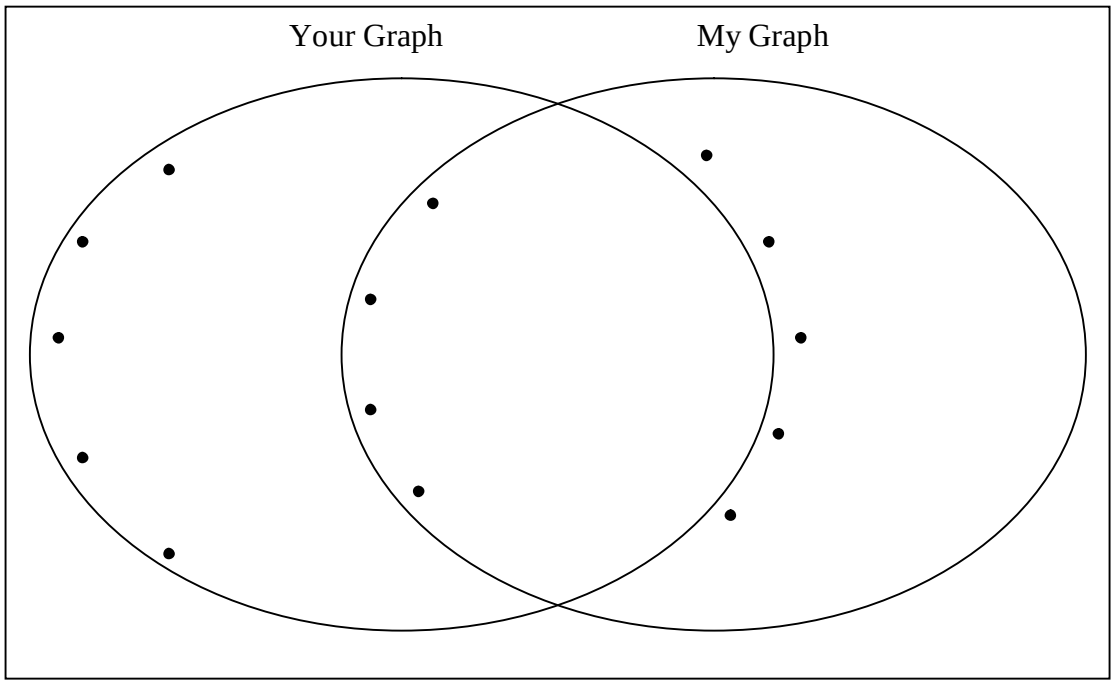
Directions: Now it's your turn to make the air-trolley move. First, as a group, decide how many legs you will have, and how you will move your trolley at each leg (Recognize that it might be difficult to be exact, but you should still set goals and try your best to achieve them. We will talk later about the difficulties you encountered here). After you have decided upon what your different legs will be, get started moving your air-trolley. At first, try without the stopwatch, just to see if you can make it move the way you want it to. Once you've mastered this, add in the time again.

Answer the questions that follow in your science journal.

1) On a separate piece of graph paper, graph your data, making sure to label each section (!) A, B, C, etc. Also label each point with a number, 1 (origin), 2, 3, etc. In your science journal, explain what is happening at each leg, and where each point is. Each leg should have at least 1-2 sentences of explanation.

2) What difficulties did your group encounter when trying to make the air-trolley move the way you wanted it to? How did you overcome these problems (what did you do to make it move, or what did you change about your expectations)?

3) What were the similarities and differences between the two graphs (mine and yours)? Create a Venn diagram, like the one below, to organize your answers. Do you think your graph makes more sense than the one I gave you? Explain why or why not.



	Novice	Competent	Expert
Process Skill	Can differentiate between dependent and independent variables, and place them on the correct axes of a graph.	Identifies loose variables (in this case, more than two directions) and tries to control them.	Sees that two-dimensional graphs cannot represent three-dimensional movement or two-dimensional movement over time.
Habit of Mind	Struggles with one or more roles. Needs prompting to contribute during group work. Must be prompted to offer evidence for their claims. Occasionally identifies anomalies.	Contributes to group work without prompting. Successfully fulfills each of the four roles. Consistently offers evidence for their assertions. Identifies anomalies in the data, and can suggest causes.	Shows leadership skills in collaborative learning, while not being overbearing. Provides hunches, and evidence for these ideas, that anticipate the direction of the lesson's content.
Concept	Has mastered positive slope, but occasionally confuses others. Can manipulate graphical data, along either axis, to make graphs model scenarios. Can calculate and compare speeds using raw data of distance, position, and time. Struggles to fit graphs to real-life scenarios, and vice versa.	Can identify the three real-world, and one impossible, slopes and articulate their meaning. Creates (draws, writes) simple scenarios of climbers changing direction and speed.	Can manipulate data algebraically, as well as on a graph. Creates (draws, writes) complex scenarios of climbers changing direction and speed.

Title: _Force and Motion Inquiry Science Lesson Plan_____

Subject/Course: _Science_____ Topic: _Acceleration _____

Designer(s): _Bill Cummiskey _____ Grade: _6_____

STAGE 1: DESIRED RESULTS

Content Standard(s):

- **MA-SC.P.11:** Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.
- **MA-SC.P.12:** Graph and interpret distance vs. time graphs for constant speed.
- **MA-SC-8.I.4** Present and explain data and findings using multiple representations, including tables, graphs, mathematical and physical models, and demonstrations

Understanding(s) *Students will understand that*:

- Objects in motion accelerate (positively, or negatively-decelerate) as their speeds change over time. This is caused by a change in the forces being applied (the pushes on) that object.
    - Gravity is one force that leads to acceleration.

Driving Question(s)

- How can I climb safely if falling could injure me?

***Students will know*:**	***Students will be able to*:**
• Acceleration, which is positive or negative, is the change in speed over time. • Gravity causes acceleration during a fall.	• Recognize acceleration in a distance vs. time graph by the slope/curve of the line. • *Day 2* Interpret, with prompting, acceleration from 'raw' data.

STAGE 2: ASSESSMENT EVIDENCE

Performance Task(s):

- Students will participate in a run/walk event that will demonstrate acceleration by comparing two objects in motion (a runner and a walker) covering different distances in a fixed period of time.
- Students will create a Treasure Map, along with graphs and narratives, which will incorporate all aspects of the motion unit.

Key Criteria:

- Recognize accelerating objects from a graph.
- Know that gravity causes falling objects to accelerate.

Other Evidence:

- Students will respond, orally and in writing, to questions regarding acceleration activity.
- Completed HW assignment.
- Graphs.

STAGE 3: LEARNING PLAN

Key: vocabulary terms, *questions for students*, **words that will eventually become vocabulary terms/items that need revision**, **appendix material**

Materials: (per group of 4)

- ❑ Poster paper.
- ❑ Photocopies of **appendices A, B, C**.
- ❑ Two mason-line tracks with time flags (regular rope 1x17m, 1x5m and vividly colored duct tape).
- ❑ 4 stakes to anchor ropes.
- ❑ 10m measuring tape.
- ❑ Stopwatch
- ❑ Traffic cones (~30)
- ❑ Overhead projector

Learning Activities:

TIME	PROCEDURE	CONCEPT
Prep	• Create two mason lines according to specifications in **Appendix C**, making sure to write in LARGER numerals, the positions of the flags for each line (from 8-0). • Chose an appropriate outdoor location. • Photocopy **appendices A, B** for students.	
Day 1 1:30-1:40	• Preview the activity: o Hand out **appendices A, B** to each student. o SAY: *This is an outdoor activity, so we have to be quick about our setup and breakdown and not waste time in transitions. Once outside, there will be two tracks set up. We will be traveling along these tracks, in pairs, to investigate an extension on the work we've been doing with distance and speed. Some of you may realize quickly what the subject of our exploration is. As always, make sure that you are respectful of your classmates and do not share your guesses until we are all ready to discuss.* o *Everyone will have plenty of opportunities to participate in all parts of the process, so be patient and while you are waiting in line, make sure that you are observing those who are moving.* o ASK*: Why is it so important to observe others doing the same thing that you're doing?*	HoM 2

	▪ Student responses should include the idea that it gives us an alternative perspective from our own experience, it allows us to create a larger sample size for our data, we might learn something about **how** to accomplish the goal from our peers, we might be able to make helpful suggestions to our peers if they are making a mistake of some kind. • Challenge Description: o SAY: *Today's challenge is to move across different distances in the same amount of time.* o DRAW on the board a picture of the activity. o SAY: *As you can see, track one is longer than track two. What else do you notice about the two different tracks?* ▪ Students' responses should include that they: start at the same point (or along the same starting line) but finish at different distances from the starting line, the intervals in line 2 are all equal, while line 1 has increasingly greater intervals, there are dotted lines linking the end of the tracks to the start of the opposite tracks. o SAY: *Now the tricky part to this process is that the person on track 1 must reach the first flag at the same time that the person on track 2 reaches their first flag, and the same is true for the second, third, and all the flags. You will be given one second to move from one flag to the next. I will call these times out for you. Both partners must move in a smooth way, no starting and stopping, no skipping, jumping or anything else like that.* o SAY: *Today, I will let you pick your own partners. What do we remember from earlier classes about how to pick our partners wisely?* ▪ Students' responses should include: not just our friends, although we can work with our friends; someone who will help us think and that we can work well with; someone we haven't worked with before, if that makes sense for us right now; don't leave anyone out.	Noticing important details, controlling for variables. Collaborative, team-building learning
1:40-1:45	• Move outside and set up the courses.	
1:45-1:47	• Review directions. • Make sure students are clear on their responsibilities.	
1:47-2:10	• Conduct the activity. • NOTE: when starting the pairs, SAY: Ready, set, ZERO to reinforce the idea that time measurement begins at zero. • Allow for repeated trials. • Students who master the idea quickly can opt to sit aside and let their peers have more chances to improve.	

	• Pause at various intervals to remind students to **think** about their motion and what is different between tracks 1 and 2.	

2:10-2:25	• ASK: *On which track was it easier to hit the numbered flags as the seconds were called out?* (Answers should mainly be track 2).
	  o *Why?* Because the distance interval was kept the same.
	  o *What's another word for 'the same?'* Constant.
	• Direct attention to **Appendix B**.
	• Project the appendix as a transparency.
	• ASK: *Who can identify something in this chart that they don't know already?*
	  o Answers should include velocity and acceleration columns.
	• Move to the poster board for <u>vocabulary</u> and add two bullets. For the first one, write <u>velocity</u>.
	  o Explain that velocity adds the idea <u>displacement</u> to our definition for <u>speed</u>. Write (abs. val. v = delta x over delta t).
	  o ASK *What is <u>displacement</u> and how do we calculate it?*
	  o <u>Displacement</u> is delta t, the different of the initial and final position, which can be **positive or negative**.
	  o Leave the second bullet point blank for now.
	• Return to the projector and redirect attention to the tables.
	• ASK: *Notice that two columns are filled in. What do they tell us?*
	  o Time and position.
	• *What was our position at flag 1 on Track 1? Flag 2? Track 2, flag 3,6?*
	• *How can we find the displacement from flag one to two?*
	  o Final position minus initial position.
	• DIRECT students to fill in the rest of the 3rd and 4th columns, and then calculate for velocity in the 5th column.
	• ASK: *Once we've completed the first five columns, how will we be able to calculate the 6th column*?
	  o Students respond that column 6 is the difference between that rows column 5 and the previous row's column 5 (final velocity minus initial velocity).
	• Allow students 10 minutes to complete the first six columns for both tables (tracks 1 and 2) in the activity pairs (this will require seat movement).
		Developing <u>vocab</u> and scientific terminology.
		
		Applying the concept of (delta = change = final-initial) to new scenarios.

2:20-2:28	• H.W. Allow students an early change to start on their H.W. • Graph the data for both track one and track 2 on a position vs. time graph. Remind students that velocity is the ratio of delta x over delta t. • Circulate to make sure students understand the directions and are creating successful graphs. • Direct students to **Appendix A** and ask them to complete the first three of the four questions.	

2:28-2:30	• Return to seats, clarify H.W.	
Day 2 1:30-1:35	• Do Now: With the person sitting next to you, share your graphs and answers from last night's H.W. If you need to make additions, do so on the sheet, but be clear about what was added and what was there from last night.	Cooperative learning, chance to incorporate new evidence (HoM 1)

1:35-1:45	• Call on students to share their answers to the three questions.
	  o Q1: Positions were 16m and 4m
	  o Q2: Track 2 had a constant, .5m/s velocity, track 1 changed, continually getting faster.
	  o Q3: There as no change in velocity for track 2, but track 1 got faster by .5m/s every new flag.
	• Introduce <u>Acceleration</u> to the students:
	• ASK: *Can anyone identify what information belongs in the 7th column of the table?*
	  o Students who have heard of acceleration or are astute enough to not it in the fourth question will respond.
	• *What is <u>acceleration</u>?*
	  o Responses should include: getting faster, putting the 'pedal to the metal,' maybe even falling.
	  o ASK: *What about getting slower?* Most will say that's deceleration.
	  ▪ Note that while this idea is correct, it is also appropriate to call it negative acceleration.
	  o *Where do we see acceleration on a daily basis?*
	  ▪ Write answers on poster paper and take 3-5 minutes to discuss.
	  ▪ Note when a student mentions **falling** and discuss <u>gravity</u> as a force that causes objects to accelerate towards the ground (or each other, if students are engaging with the concept on a high level).
	• Show students that acceleration is the change of speed over an interval of time. Direct their attention to the units in the 6th and 7th columns, and, working with students, derive from (m/s)/s the unit m/s^2. (Students should have seen division with fractions already, and can follow multiplication by the reciprocal.)
	• Explain that, for the purposes of science this year, acceleration is not something that we expect students to be able to calculate or find from a graph. However, it is a concept that they have to understand. Students should be able to recognize acceleration in tables or graphs. ASK: *How do we see acceleration in a graph?*
	  o Answers should include: lines that are curving up (make sure that they also mention curving down) rather than going in a straight line are changing their slopes and thus are changing velocity (make sure they use velocity, rather than speed).	

	• Project the tables for both tracts and collectively fill in the 7th columns. • Students record data on their own sheets as well. • Collect both appendix handouts.	

1:45-2:28	• Begin culminating project: Move to the poster board papers and ASK: *What have we discovered about motion so far this unit?*
	  o Answers should include: distance (delta x), displacement, speed, velocity (v), position(x), initial position, final position, reference point, graphing distance over time, position over time, acceleration, controlling variables, the slope of a line is its speed/velocity.
	• Tell students that today marks the beginning of their culminating activity. Students will be creating a treasure map that includes all the aspects of motion that we have discovered so far.
	• Hand out project description.
	• Have a student read the letter aloud.
	• Read over the directions of the project with everyone.
	• Pass out poster sheets and have students gather materials.
	• Work on maps for the duration of the period.
	  o Circulate among students to check for understanding.
	  o Ask how they are planning to use each of the various elements of the unit.
	  o Clarify directions, when necessary.	

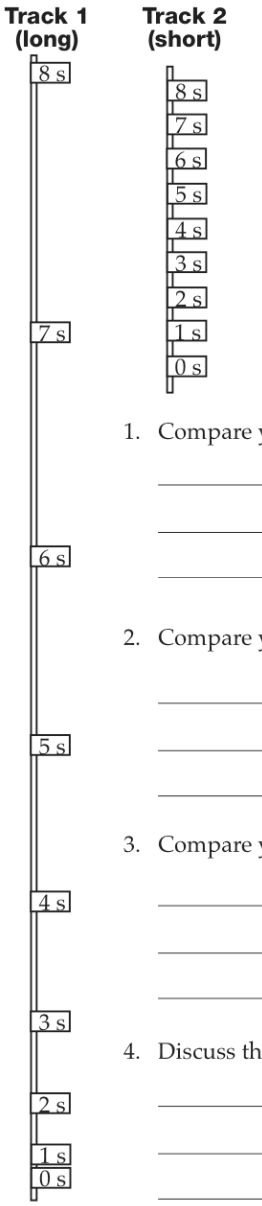
2:28-2:30	• Clean up. • Explain that we will work on the project for the remainder of the week (These lesson plans not included).	

Appendix A

Name _____

Period _____ Date _____

COMPARING TRACKS A



Walk the length of the long track and the short track.

Walk at a speed that will bring you to each number as it is called out. (The whole walk will take 8 seconds.)

The distance from the start (0 seconds) to each of the numbers is recorded in the data tables. Fill in the rest of both data tables.

Make position-versus-time graphs for both tracks.

1. Compare your positions (x) on the two tracks after 8 seconds.

_____

_____

_____

2. Compare your velocities ($\bar{v}$) as you traveled on the two tracks.

_____

_____

_____

3. Compare your change of velocity ($\Delta\bar{v}$) as you traveled the two tracks.

_____

_____

_____

4. Discuss the difference between constant velocity and acceleration.

_____

_____

_____

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Appendix B

Name _____

Period _____ Date _____

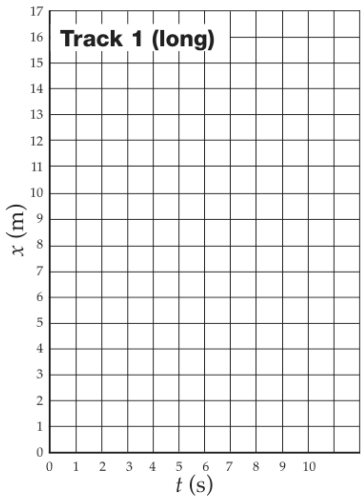
COMPARING TRACKS B

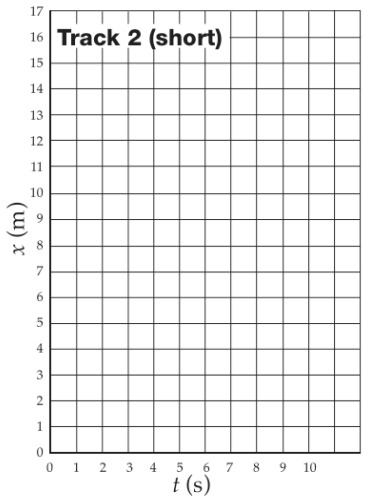
Track 1 (long)

t (s)	x (m)	Δx (m)	Δt (s)	$\bar{v}$ (m/s)	$\Delta\bar{v}$ (m/s)	a (m/s^2)
0	0					
1	0.25					
2	1.0					
3	2.25					
4	4.0					
5	6.25					
6	9.0					
7	12.25					
8	16.0					

Track 2 (short)

t (s)	x (m)	Δx (m)	Δt (s)	$\bar{v}$ (m/s)	$\Delta\bar{v}$ (m/s)	a (m/s^2)
0	0					
1	0.5					
2	1.0					
3	1.5					
4	2.0					
5	2.5					
6	3.0					
7	3.5					
8	4.0					





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Appendix C

Flag	Position of flag for track 1 (in meters)	Position of flag for track 2 (in meters)
8	16.00	4.00
7	12.25	3.50
6	9.00	3.00
5	6.25	2.50
4	4.00	2.00
3	2.25	1.50
2	1.00	1.00
1	0.25	0.50
0	0.00	0.00

	Novice	Competent	Expert
Process Skill	Can differentiate between dependent and independent variables, and place them on the correct axes of a graph. Needs graph to recognize acceleration.	Identifies loose variables (in this case, more than two directions) and tries to control them. Can, with some prompting, interpret whether an object is accelerating from raw data.	Sees that two-dimensional graphs cannot represent three-dimensional movement or two-dimensional movement over time. Can, without prompting, interpret whether an object is accelerating from raw data.
Habit of Mind	Struggles with one or more roles. Needs prompting to contribute during group work. Must be prompted to offer evidence for their claims. Occasionally identifies anomalies.	Contributes to group work without prompting. Successfully fulfills each of the four roles. Consistently offers evidence for their assertions. Identifies anomalies in the data, and can suggest causes.	Shows leadership skills in collaborative learning, while not being overbearing. > Helps peers while not giving away the nature of the lesson. Provides hunches, and evidence for these ideas, that anticipate the direction of the lesson's content.
Concept	Can identify the three real-world, and one impossible, slopes and articulate their meaning. Can recognize acceleration on a graph, but does not see the connection to velocity.	**Day 1:** Has a hunch that we are working with acceleration, and can offer (individually) a naïve definition of the term. **Day 2:** Knows that acceleration is the change of velocity over time, that it can be positive or negative, and is represented graphically by a curved slope.	**Day 1:** Knows that the lesson is about acceleration and can offer a hunch as to the slope of a graph of an accelerating object. Can manipulate data algebraically, as well as on a graph.

Treasure Island

Dear Treasure Seeker,

I have heard, from very reliable sources, that you are in possession of a certain map leading to the infamous Treasure Island. I also understand that you have been, up to this time, unable to retrieve this fortune in gold and jewels, due to a lack of resources. My friend, your time has come.

I, too, am an ardent treasure fanatic, but not for the money. No, no. In fact, I have more of that than I know what to do with. Rather, I enjoy the excitement of the challenge, overcoming the skills and intrigue of those who sought to keep their prized possessions safe from future generations. I have delved the tombs of the Egyptian Pharaohs, trekked through the swampy forests of Brazil, and climbed the hidden peaks of the Himalayas, all in search of treasure and adventure. I have even found, in the confusion of the Mediterranean Sea, the very island that holds the treasure we both seek. Now, all I need is a map.

If it is true that you have obtained this very, very valuable information, all that is required is that you prove its worth. Write me with a time and place of your choosing, so that we can meet and form a mutual agreement in our search for the treasure.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

At the date of our meeting, bring along a copy of the treasure map. I know the island is quite mountainous, and so I hope that it contains, in great detail, the route we must take.

Write soon, so that we can find this treasure together, and make us both rich and famous, beyond your wildest dreams.

Sincerely,

A Friend

Name: Date:

Treasure Island Project

TIFF (Uncompressed) decompressor
are needed to see this picture.

Your project is to create a treasure map that includes all the aspects of our Motion unit. There will be three parts to the project. Each will be assessed on how well you demonstrate understanding of the concepts involved with motion, how much effort was put into the assignment, and how creative you were in designing and displaying your information.

Part 1: The map

Your map will fill up a poster paper that I will give to you. It should depict an island similar to the description from the letter you received. On the map, you must include:

- ❑ A point of reference (where does the treasure path being)
- ❑ A detailed path that covers the majority of the island
- ❑ A scale (in metric units) of the island
- ❑ A legend (for any major markers, your path, etc.)
- ❑ Position markers along the way (with relative distances between)
  - o At least 5
- ❑ Time estimates for each of these markers
- ❑ Colorful pictures and backgrounds
- ❑ At least one cliff that must be climbed
- ❑ An X, to mark the spot of course

Part 2: Graphing your map

You will hand in two separate graphs, representing the information you created for your map. The *first* graph will be a distance vs. time line graph for the whole trip. Estimate the time for each of the position markers on the course, with reasonable explanations for why it will take that amount of time. Calculate the speed for each of these legs. Make sure to include a table of values for all of your data.

The *second* graph will be a position vs. time graph of your ascent/descent of the cliff. Depending upon whether you are climbing up or down, create an appropriate graph that represents the motion of the climber on the cliff. Accompanying this graph, you must create a drawing of the cliff, and the best route for climbing it. Your graph must include at least three stops (with reasonable explanations) and four changes of direction.

Part 3: Describing the trip

You will write a first-person, narrative account of traveling along the path of the map. From your beginning reference point to the X at the treasure, describe what you see and do as you follow the path. When is it ascending, when descending? What is your relative speed, how far until the next position marker, which direction are you traveling (use cardinal compass directions). Each leg of your journey should take a paragraph to describe.

If you would like, you and a partner can tape a video of a portion of your trip (be imaginative- you could do this in a local park). The video should match your map. Include markers of some sort to show distance traveled, heights, etc. Make sure that your paragraphs describe and explain the video segment, where it was on your treasure map, what motion was taking place, and how various elements of motion could be calculated from the video. Submit this with your project on a DVD or electronically.

Score	Map	Graphs	Narrative Description	Effort	Creativity
4 Exceeds Expectations (Must include at least some of these criteria)	*Meets requirement for a 3* • Legs are complex and varied. • Includes at least two extra legs. • Distances are specific to the meter.	*Meets requirement for a 3* • Includes an additional elevation graph of one leg of the path. • Graphs are fully colored and labeled.	*Meets requirement for a 3* • Writing includes sensory details. • Descriptions are longer than one paragraph each. • Includes fictional, imaginative descriptions of the island.	• Assists others.	• Exceptionally creative. • Includes more than 3 hand-drawn markers. • Description is illustrated.
3 Mastery of Concepts and Skills	*Includes all requirements.* • Distances are clear and reasonable. • Time increments are clear and reasonable. • Point of reference is present. • Path covers most of island • Legend includes all-important details.	*Includes all requirements* • Graphs are well drawn or made in excel. • Axes are correctly labeled. • Scales are reasonable. • Calculations are clear and accurate. • Table is correctly labeled and complete.	*Includes all requirements* • Few or no spelling or grammar errors. • Details are included for every leg. • Variation is present among the legs. • Is in first person. • Appropriate length	• Requires few, and non-repetitive reminders to remain on task. • On-time. • Completes work at home and in class.	• All parts of the project are colored. • Everything is neat. No pencil marks, no eraser marks. • No scribbling. • Includes 3 hand-drawn markers.
2 Well Done; Needs Improvement					
1 Unacceptable; Must be Redone					

Note: This would be a rubric that we would create as a class. I have included mastery for the content areas, as well as samples for above and beyond. The class would collaborate to create this information, so that they would have greater ownership of the project and understanding of the assignments and requirements.

Due to the length and comprehensive nature of the lesson plans developed for this course, reflection and revision become a daunting task. In analyzing my plan, however, and in response to the feedback before and during class, a few themes have presented themselves. I hope to take these themes and, both within the document itself, and in a more fluid, spontaneous manner while teaching.

The first theme I've discerned is the need to attend to details, during both the planning and implementation stages. This came through in comments during class regarding my handwriting on the board. I definitely needed to slow down and write clearly. Improving this will greatly help those students who are visual learners and need to see the concepts we are developing collaboratively. The theme of focusing on details extends further, to the placement of materials around the room, preparation during setup, positioning of poster papers and instructions. Multiple times while I was teaching last weekend, I felt confused and frustrated by disorganized materials or improper placement. It was difficult to control the flow of the exploration without a centrally located materials desk, where each getter could come for materials while I simultaneously observed the groups at work. Similarly, placement of markers, poster paper and diagrams (for reference) were frequently in hard-to-get-to places. To fix these difficulties, I would have to develop a familiarity with my teaching space and the dynamics the space created. Obviously, that would have been difficult to achieve last weekend, but it is helpful to know that for future teaching.

The second theme that I noticed while teaching this lesson in school was the difficulty of successfully assessing students during the class period. As I walked around the room and asked facilitating or formative assessment questions, I was often impressed with the students' understanding of the subject. Many other times I was able to tease out creative solutions or thoughtful responses after a number of questions. Even so, at the end of the period I felt at a loss for naming the students who understood the lesson as a whole, let alone distinguishing the specific concepts and skills that each individual had demonstrated mastery of. To improve upon this, I plan to revisit my lesson plan and create a formative assessment checklist. Each student's name will be listed down the page, with very specific concepts or skills listed across the top. These concepts or skills would match various questions developed earlier, so that I will know which boxes to check based upon what (type of) question the student is answering. This should allow me to hone my lesson, clarifying the areas that seem to reflect least understanding, and keeping those questions that proved most successful in assessing knowledge.

Closely related to this idea was a need for refinement in the homework and written assignments. Most of the courses I have taught before have had a wealth of handout-type resources for homework. The principle that these assignments stand on is that practice and repetition breed understanding. Since the inquiry-based learning cycle denies the universality of this assumption (although repetition can serve its purpose), creating novel, interesting, and pointed assessments was very difficult. I was pleased with my first homework assignment, as it successfully included family members or members of the community with our schoolwork. This assignment also required students to articulate the activity and its purpose. It was clear, from the questions they brought back, that some of their descriptions were unclear. These questions were much more vague, less focused on the topic of motion and distance than the 'fun' aspects of the activity. By reviewing these questions within groups, I meant for students to compare

their feedback. In future lessons, when using this type of assessment, I would take more time to specifically compare some of the responses, asking students to repeat their explanations and discussing what *types* of questions resulting from different explanations. This, however, would have to be done carefully, so as not to embarrass anyone because of his or her family.

Finally, timing is an important area that needs improvement. My first lesson definitely needs more than one hour to allow the students to become familiar with using the apparatus. Talking through the process, helping students realize that many of their trials are skewed because of uncontrolled variables, and finalizing a systematic way of creating and controlling motion required multiple starts and stops. I had to initiate whole-class conversations, as well individual and intra-group discussions, to lead students to a more 'scientific' process. This difficulty would be partially improved by creating a more scientifically minded class from the outset. Without teaching from the beginning of the year, many of the habits of mind that would have been instilled by this time of year were missing. With these habits in place, many of the sections of the lesson would take less time. Nevertheless, there are parts of the lesson, especially the third day, that would require more time regardless. Creating graphs on the computer and by hand, as well as giving enough time to each group to help them start their lab write-ups, would require at least 90 minutes.

If I had more time, one of the things that I would do is take a closer look at curriculum, such as STC, that deal with force and motion in a different way. Although I did glance through these resources, for the most part my unit followed the FOSS schedule. While FOSS worked from ideas of distance and speed to concepts of force, STC moved in the opposite direction. It would have been interesting to see how those units aligned in ways that would allow me to combine resources or replace parts of my current plan with more intriguing or engaging activities.

In a similar way, I would love to take a look at math curriculum dealing with rates and proportions and ratios, as well as data and graphing. These concepts are in great abundance throughout my unit, and more time spent with the *ideas* of rates and the *purposes* of graphs would greatly improve the understanding of students. Having taught sixth grade for almost three years, and even seventh and eighth grades, students struggle with the idea of rates, units and proportions. In the future, I would find math-based resources that could be converted to science classes or taught in tandem within the students' math program (of course, an actual interdisciplinary unit would serve this purpose best).

Overall, I was pleased with the way the lesson worked with both adults and sixth grader students. Keeping on track, while juggling the materials, directions, discussions and formative assessment will, I hope, become easier and more manageable as I mature as a teacher.