



Teacher-to-Teacher

Video Series
for Secondary Educators

TITLE: “Measurement in Motion”

PRIMARY SUBJECT AREA: Physical Science

GRADE LEVEL: 9

OVERVIEW: This lesson focuses on manipulating and analyzing quantitative data using the SI system. Data is generated on rate of motion and changes in motion using a ramp and a rolling object. The data is then averaged and analyzed.

APPROXIMATE DURATION: two 50-minute class periods or one 90-100 minute block class

LOUISIANA CONTENT STANDARDS:

<http://www/DOE/assessment/standards/SCIENCE/pdf>

Science as Inquiry

Benchmarks:

- SI-H-A2 designing and conducting scientific investigations.
- SI-H-A3 using technology and mathematics to improve investigations and communications.

SI GLEs:

4. Conduct an investigation that includes multiple trials and record, organize, and display data appropriately (SI-H-A2)
- 5 Utilize mathematics, organizational tools, and graphing skills to solve problems (SI-H-A3)

Physical Science

Benchmarks:

- PS-H-A1 manipulating and analyzing quantitative data using the SI system;
- PS-H-E2 understanding the relationship of displacement, time, rate of motion, and rate of change of motion; representing rate and changes of motion mathematically and graphically;

PS GLEs:

1. Measure the physical properties of different forms of matter in metric system units (e.g., length, mass, volume, temperature) (PS-H-A1)
2. Gather and organize data in charts, tables, and graphs (PS-H-A1)
31. Differentiate between speed and velocity (PS-H-E2)
32. Plot and compare line graphs of acceleration and velocity (PS-H-E2)

EDUCATIONAL TECHNOLOGY GUIDELINES:

<http://www/DOE/LCET/curric/cats.asp>.

Technology Research Tools (*Linking and Generating Knowledge Foundation Skill*)

Students use technology tools to process data and report results.

INTERDISCIPLINARY CONNECTIONS:

- M-1-H selecting and using appropriate units, techniques, and tools to measure quantities in order to achieve specified degrees of precision, accuracy, and error (or tolerance) of measurements;
- M-4-H demonstrating the concept of measurement as it applies to real-world experiences; and
- D-7-H making inferences from data that are organized in charts, tables, and graphs. (e.g., pictograph; bar, line, or circle graph; stem-and-leaf plot or scatter plot);

OBJECTIVES:

1. The student will conduct an investigation.
2. The student will record data in metric units
3. The student will determine the average speed of a rolling object.
4. The student will analyze data.
5. The student will determine the forces that affect the object's forward motion.
6. The student will describe how a moving object can have zero acceleration and deceleration.

LESSON MATERIALS AND RESOURCES:

A bowling ball, basketball, or volleyball

A wood ramp (approximately 60 cm long)

A three meter sticks can be taped together if a smooth length of wood is not readily available.

Masking tape (to mark off the distances that will be used in the calculations)

Meter stick(s) to measure the distances

Stack of books or other objects to raise one end of the ramp approximately 20 cm from the floor

Toy car, truck, or ball to roll down the ramp

Stop watch or wristwatch with second hand

ATTACHMENTS:

Student data tables (A1)

Rubric (A2)

Constructed Response Assessment (A3)

Teacher Key (A4)

TECHNOLOGY TOOLS AND MATERIALS:

These will be included in "Explorations and Extensions."

BACKGROUND INFORMATION:

Students should know how to collect data, plot data on a graph, calculate an average, calculate speed when distance and time are known, use a stopwatch or read time using the second hand of a wristwatch, and know the SI units for distance, time, and speed.

LESSON PROCEDURES:

Anticipatory Set: The teacher rolls a bowling ball, basketball, or volleyball across the front of the classroom. The ball can then be rolled down each aisle or a couple of aisles in the classroom. Students should orally describe the motion of the ball without scientific terms and then write the description, using scientific terms regarding motion. The descriptions may be written in their science journals. The teacher then conducts a discussion by using questions directed at establishing the students' level of understanding of motion in a straight line.

Questions might include the following:

Why does the ball not stop immediately after being released?

Why does the ball eventually stop? What determines when the ball stops rolling?

Why does the ball not travel in a curved path or in a circle?

How would you describe the speed of the ball from release to full stop?

How would they calculate the speed of the bowling ball?

How would a carpeted floor affect the motion of the ball?

Lesson:

The teacher transitions by relating an overview of the first activity.

Part A – Average Speed

1. Use the aisle between desks or the hallway outside of the classroom. This “runway” should be uncarpeted and mostly smooth in order that the object rolls approximately five meters from the bottom of the ramp. Each group of students will need at least six meters of runway space.
2. At one end of the runway, set up the “launching ramp.” Place one end of the ramp on the stack of books and the other end of the ramp on the floor. The object will be launched from the top of this ramp.
3. Place a piece of masking tape where the ramp touches the floor. Label this marker 0.0 meter. Place and mark similar pieces of tape at 1.0 meter, 2.0 meters, 3.0 meters, 4.0 meters, 5.0 meters, and 6.0 meters.
4. Practice launching the toy or ball down the ramp several times to observe its motion and its path. Books may need to be added or removed from the launching end of the ramp so that the toy or ball travels at least 5.0 meters from the 0.0 marker.
5. Measure the time that the toy or ball takes to travel the 5.0 meters. Remember that the 5.0-meter distance begins at the bottom of the ramp. Record the time and distance on the student data table, Attachment A1.
6. Record the time and distance for three more trials. Calculate the average distance and time of the four trials and enter them in the data table 1.
7. Calculate the average speed of the object, to the nearest 0.1 meters per second, using the formula:
$$\text{average speed} = \frac{\text{avg. distance}}{\text{avg. time}}$$

Part B – Deceleration

1. Repeat steps 4 and 5 from Part A again; however, this time, measure the time as the car or ball crosses each meter marker. This part of the investigation will require several practice runs to be able to quickly observe and record the time. One or two lab partners can measure the time. This would require two lab partners to record these times. The times can be averaged before recording on Data Table 2.

2. Make a total of four trials. Record the time (or averaged time) traveled as the object crosses each meter mark. Calculate the average time for the four trials of each meter mark and enter this average on Data Table 2.
3. Use the average time for each distance mark to calculate the average speed at each marker. Record the average speed to the nearest m/s. Record this information in Data Table 2.

DATA AND OBSERVATIONS (Attachment A1)

Part A- Average Speed

Data Table 1

Part B – Deceleration

Data Table 2

Graphing Grid

Make a line graph to compare the distance to each marker (x axis) with the speed of the car (y axis).

ASSESSMENT PROCEDURES:

There are several opportunities for formal and informal, summative, and formative assessment. If there is not enough time to complete the graph and/or constructed response questions, they may be assigned for homework. One method of checking homework is for degree of completion. If most or all of the assignment is attempted, then students earn a “+;” if at least half is attempted, then the “grade” is $\frac{1}{2}$; if very little or none is attempted, then the student(s) earn a “-.” It is not always appropriate to check homework for accuracy; that is a decision that the teacher makes by considering the purpose of the assignment and the students’ level of expertise with the assignment.

A rubric, Attachment A2, is included if the teacher wishes to customize it further. Constructed response items on included on Attachment A3.

ACCOMMODATIONS/MODIFICATIONS:

Accommodations/modifications that can be made would include allowing students with exceptional needs to be the timekeeper or recorder. If a six meter countertop or table is available, it can be used for students who cannot sit on the floor to launch the toy car, truck, or ball.

REPRODUCIBLE MATERIALS:

Attachment A1 - Student Data (Data Table 1, Data Table 2, and Graphing Grid)

Attachment A2 - Rubric

Attachment A3 - Constructed Response Items

EXPLORATION AND EXTENSION:

Students could design and/or build a roller coaster or water slide that would meet approximate speeds specified by the students.

LESSON DEVELOPMENT RESOURCES:

Focus on Physical Science, Teacher's Resource Manual,(1981), pages 19-22; Columbus, OH; Charles E. Merrill Publishing Co.

Gartrell, Jack E., Jr., (1989). *methods of motion*, (Rev.ed.).Washington, D.C., National Science Teachers Association, pp 31-68.

<http://www.learner.org/exhibits/parkphysics>

<http://marcopolo.worldcom.com/>

<http://www.physics.gatech.edu/academics/>

<http://www.mcrel.org/>

REFLECTIONS:

The students enjoyed the opportunity to get out of their desks and “play” on the floor. This activity provides a good opportunity for students to conceptually understand constant speed and acceleration. The plot is another great opportunity for students to “see” what speed that is not constant “looks” like.

We found that tennis balls and golf balls worked well as the rolling objects.

If your students are very weak in graphing skills, Prentice Hall had a great series of “Brainstretchers” in their 1987 teachers’ resource material for physical science. It was in a section entitled “Graphing Skills”. The “Brainstretchers” ranged from the “jargon of graphing” to identifying the parts of a data table/chart, through constructing a simple best-fit curve.

Another very good source for improving very basic graphing skills is Amsco Publisher’s *Mastering Basic Skills in Science*.

If your students have the technology, the data can be entered in an Excel® chart and then graphed in Excel®.

I recommend two timers and two recorders in Part B, because the rolling object travels very quickly across the first three markers. The ramp should be just high enough for the object to roll the 5 meters. If the ramp is too low, the object might not stop before the 5-meter mark. If the ramp is too high, the object will roll too fast for the timers.

Ramps can be just plain wooden boards; I used movable shelves from a discarded bookcase. We taped meter sticks to the sides of the shelves in order to keep the object on the ramp. A student later made ramps for us for extra credit. Timers and balls can be borrowed from the P.E. department.

If you do not have enough material for groups of students, this activity could be done as a demonstration, involving some of the students. A student can release the object and two or three students could time the trials. Another group of students could serve as timers for additional trials. Remember to always try demonstrations/activities before doing them in class.

CONTACT INFORMATION:

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Student Name: _____
 Class Period: _____

Date: _____

DATA AND OBSERVATIONS

Part A – Average Speed

Data Table 1

TRIAL #	DISTANCE (m)	TIME (s)
1	5.0	
2		
3		
4		
5		
average		

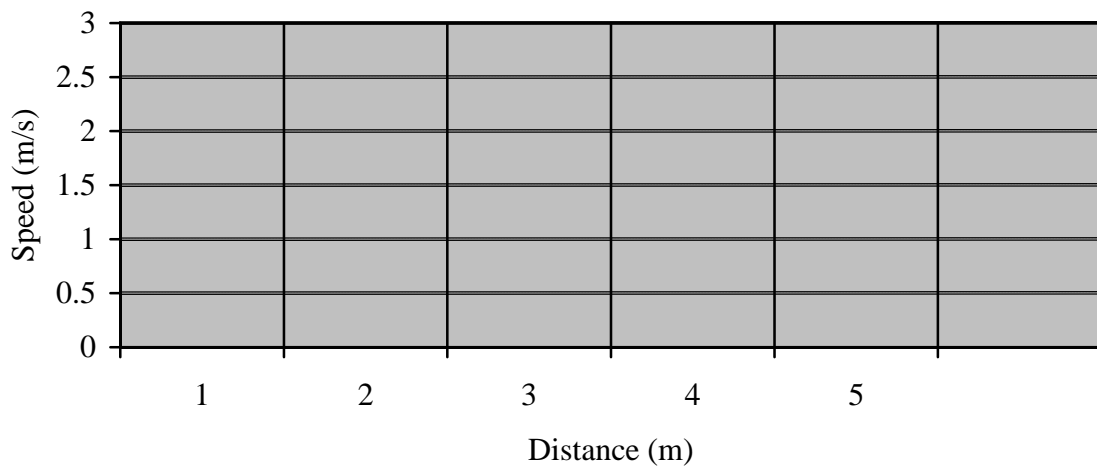
The average speed is measured in m/s

Part B – Deceleration

Data Table 2

TRIAL	TIME (s)				
	1.0 meter	2.0 meters	3.0 meters	4.0 meters	5.0 meters
1					
2					
3					
4					
Average time (s)					
Speed at each marker (m/s)					

Distance vs Speed Graph



Lab Report: "Measurement In Motion"

Student Name _____

Class Period _____ Date _____

Category	4	3	2	1
Components of the report	All required elements are present an additional elements that add to the report (e.g., thoughtful comments, graphics) have been added.	All required elements are present.	One required element is missing but additional elements that add to the report (e.g., thoughtful comments, graphics) have been added.	Several required elements are missing.
Participation	Used time well in lab and focused attention on the experiment.	Used time pretty well. Stayed focused on the experiment most of the time.	Did the lab but did not appear very interested. Focus was lost on several occasions.	Participation was minimal OR student was hostile about participating.
Calculations	All calculations are shown and the results are correct and labeled appropriately.	Some calculations are shown and the results are correct and labeled properly.	Some calculations are shown and the results labeled appropriately.	No calculations are shown OR results are inaccurate or mislabeled.
Analysis	The relationship between the variables is discussed and trends/patterns logically analyzed. Predictions are made about what might happen if part of the lab were changed or how the experiment design could be changed.	The relationship between the variables is discussed and trend/patterns logically analyzed.	The relationship between the variables is discussed but no patterns, trends, or predictions are made based on the data.	The relationship between the variables is not discussed.

Safety	Lab is carried out with full attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual.	Lab is generally carried out with attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual, but one safety procedure needs to be reviewed.	Lab is carried out with some attention to relevant safety procedures. The set-up, experiment, and tear-down posed no threat to any individual, but several safety procedures need to be reviewed.	Safety procedures were ignored and/or some aspect of the experiment posed a threat to the safety of the student or others.
Scientific Concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.
Variables	All variables are clearly described with all relevant details.	All variables are clearly described with most relevant details.	Most variables are clearly described with most relevant details.	Variables are not described OR the majority lack sufficient detail.
Data	Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representation of the data in tables and/or graphs. Graphs and tables are labeled and titled.	Accurate representations of the data in written form, but no graphs or tables are presented.	Data not shown OR are inaccurate.

TOTAL POSSIBLE POINTS: 32

NUMBER OF POINTS EARNED: _____

Name _____
Class Period _____ Date _____

CONSTRUCTED-RESPONSE ITEMS

Part A – Average Speed

1. What was the independent variable?
2. What was the dependent variable?
3. List two variable/conditions that were held constant during each trial.
4. What was the purpose of conducting more than one trial?

Part B – Deceleration

1. What was the independent variable?
2. What was the dependent variable?
3. List two variable/conditions that were held constant during each trial.
4. What force caused the rolling object to move down the ramp?
5. What caused the car to slow down?
6. From the graph that you made, explain if the rolling object traveled at a constant speed.
7. When did the rolling object accelerate?
8. When did the object decelerate?
9. How could you change this activity to make the rolling object decelerate at a faster rate?

10. How could you change this activity to make the rolling object accelerate at a faster rate?

11. Explain if a bar graph would be more appropriate to display this data.

12. If you were redesigning this experiment, explain how you could get the car to travel with zero acceleration and zero deceleration.

Attachment A- 4

TEACHER'S KEY

CONSTRUCTED-RESPONSE ITEMS

Part A – Average Speed

1. What was the independent variable?
time
2. What was the dependent variable?
speed
3. List two variable/conditions that were held constant during each trial.
distance, the rolling object, ramp, or height of ramp
4. What was the purpose of conducting more than one trial?
reduce error; increase accuracy, confirm data

Part B – Deceleration

1. What was the independent variable?
distance
2. What was the dependent variable?
speed
3. List two variable/conditions that were held constant during each trial.
the rolling object, ramp, or height of ramp
4. What force caused the rolling object to move down the ramp?
after the release, gravity was the force.
5. What caused the car to slow down?
friction
6. From the graph that you made, explain if the rolling object traveled at a constant speed.
The object did not travel at a constant speed, because the graphed line curved down, indicating the car was slowing down.
7. When did the rolling object accelerate?
As the speed changed after the object was released.
8. When did the object decelerate?
When the rate of change in speed decreased.

9. How could you change this activity to make the rolling object decelerate at a faster rate?
Use a heavier rolling object; increase friction (carpeted track); or change the path to uphill rather than downhill
10. How could you change this activity to make the rolling object accelerate at a faster rate?
Increase the height of the ramp; shorten the ramp; or push the object down the ramp, rather than just releasing it.
11. Explain if a bar graph would be more appropriate to display this data.
A Bar Graph is used when comparing numbers that have no effect of each other. The Line Graph is more appropriate because it represents change over time.
12. If you were redesigning this experiment, explain how you could get the car to travel with zero acceleration and zero deceleration.
Traveling on a surface similar to ice skaters would give results closest to zero acceleration and zero deceleration.