Explore/Explain Phase 1 – Motion

Purpose:
Explore data collection using a CBR and a graphing calculator in order to investigate functions. Utilize graphing calculator technology to develop function rules. Communicate findings using a word processor and TI-Connect to upload calculator screenshots.

Descriptor:
Participants will collect linear data using a motion sensor such as a CBR. They will make scatterplots, find appropriate trend lines, identify slopes and *y*-intercepts, and explain the meaning of each in this situation. Participants will communicate results using TI-Connect and Microsoft Word.

Duration:
2.5 hours

TEKS:
A.1(B) Gather and record data and use data sets to determine functional relationships between quantities.

A.1(C) Describe functional relationships for given problem situations and write equations or inequalities to answer questions arising from the situations;

A.1(D) Represent relationships among quantities using concrete models, tables, graphs, diagrams, verbal descriptions, equations, and inequalities; and

A.1(E) Interpret and make decisions, predictions, and critical judgments from functional relationships.

A.2(B) Identify mathematical domains and ranges and determine reasonable domain and range values for given situations, both continuous and discrete.

A.2(D) Collect and organize data, make and interpret scatterplots (including recognizing positive, negative, or no correlation for data approximating linear situations), and model, predict, and make decisions and critical judgments in problem situations.

A.5(A) Determine whether or not given situations can be represented by linear functions.

A.5(B) Determine the domain and range values for which linear functions make sense for given situations.

A.5(C) Use, translate, and make connections among algebraic, tabular, graphical, or verbal descriptions of linear functions.

A.6(A) Develop the concept of slope as rate of change and determine slopes from graphs, tables, and algebraic representations.

A.6(B) Interpret the meaning of slope and intercepts in situations using data, symbolic representations, or graphs.

A.6(C) Investigate, describe, and predict the effects of changes in m and b on the graph of $y = mx + b$.

A.6(F) Interpret and predict the effects of changing slope and y-intercept in applied situations.

A.9(A) Determine the domain and range for quadratic functions in given situations.
A.9 (B) Investigate, describe, and predict the effects of changes in *a* on the graph of $y = ax^2 + c$.
A.9 (C) Investigate, describe, and predict the effects of changes in *c* on the graph of $y = ax^2 + c$.
A.9(D) Analyze graphs of quadratic functions and draw conclusions.
A.10(A) Solve quadratic equations using concrete models, tables, graphs, and algebraic methods.

TAKS:

- Objective 1: Functional Relationships
- Objective 2: Properties and Attributes of Functions
- Objective 3: Linear Functions
- Objective 5: Quadratic and Other Nonlinear Functions
- Objective 10: Mathematical Processes and Mathematical Tools

Technology:

- Internet
- CBR
- Hand-held graphing calculator
- TI Connect Version 1.6 or higher
- Graph link technology
- Word processing technology

Materials:

Advanced Preparation:

- Build CBR roll cage, one for each group
- Collect materials for each group
- Make sure the RANGER application is on all calculators

For the presenter:

- Data projection device
- Overhead graphing calculator
- Overhead projector

For each participant:

- Graphing calculator
- Graph link (optional)
- **Motion** activity sheets, Parts 1-5
- **Motion Intentional Use of Data** activity sheet printed on green paper

For each group of 4 participants:

- Access to a computer and the Internet
- CBR, graphing calculator, and graph link
- Copy of the Technology Tutorial
- Meter stick
- Self-propelled toy car
- Action figure with parachute
- Yo-yo
- Basketball
- Straw
- Racquetball
- Coffee filter
- Small rubber ball (about 1 inch in diameter)
- Ping pong ball
- CBR roll cage
- Large, hard-bound book (such as a dictionary)
- Jumpdrive (optional)

Leader Notes:

The information in the next few paragraphs is included to provide background information to assist the presenter. It is not designed to be presented directly to participants.

This activity requires participants to make conjectures, design experiments to collect data, and to analyze data to verify their conjectures. They will be using a calculator-based data collection device called a Calculator Based Ranger (CBR). The CBR uses a sonic pulse to measure an object's distance from the CBR at a point in time. The device collects 99 samples within a user chosen timeframe. The distance can be measured in meters or feet. It has a range of about 18 inches to 15 feet. The CBR must be connected to a user calculator that has either the CBL/CBR APP or the RANGER program loaded on it. These programs will allow participants to analyze distance vs. time, velocity vs. time, or acceleration vs. time relationships.

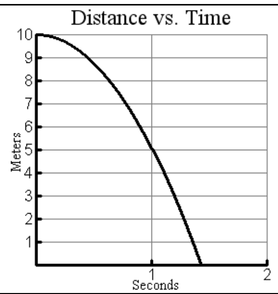
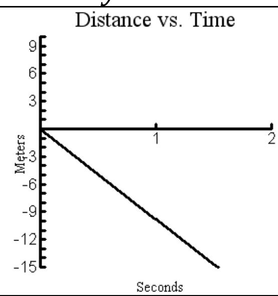
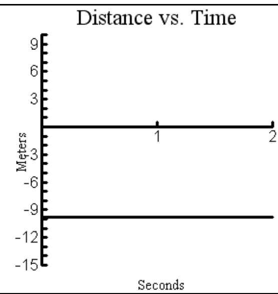
Since participants will be investigating linear and nonlinear relationships, some discussion of the relationships among distance, velocity, acceleration, and time might be helpful to some presenters.

The speed of an object is the distance that it travels over a given time interval.

The velocity of an object is its directed speed. For example, velocity is positive if the object is moving away from the point of measurement, and velocity is negative if it is moving toward the point of measurement. The velocity is the change in distance over the change in time. If this sounds like the equation for slope, it should because velocity is the slope of the distance vs. time curve at that point in time. If distance vs. time is a linear relationship, then its slope is constant, thus the velocity is constant. If distance vs. time is nonlinear, quadratic for example, then the velocity is changing and its graph will be curved.

The acceleration of an object is its change in velocity. The acceleration is the slope of the velocity curve. If an object is speeding up or slowing down then it has acceleration, if the object is moving at a constant velocity then the acceleration is 0.

The following example of a ball dropped from 10 meters in a vacuum is used to demonstrate the relationships between distance, velocity, and acceleration.
The position of a moving object can be found using the following equation $d = -\frac{1}{2}at^2 + v_0t + d_0$*, where* d_0 *is the initial distance from the point of measurement,* v_0 *is the initial velocity, t is time, and a is the acceleration that acts on the object.*
Since the ball is being dropped from 10 meters, v_0 *is* $0\frac{m}{s}$*, and* d_0 *is 10 meters. The acceleration due to gravity is* $-9.8\frac{m}{s^2}$.

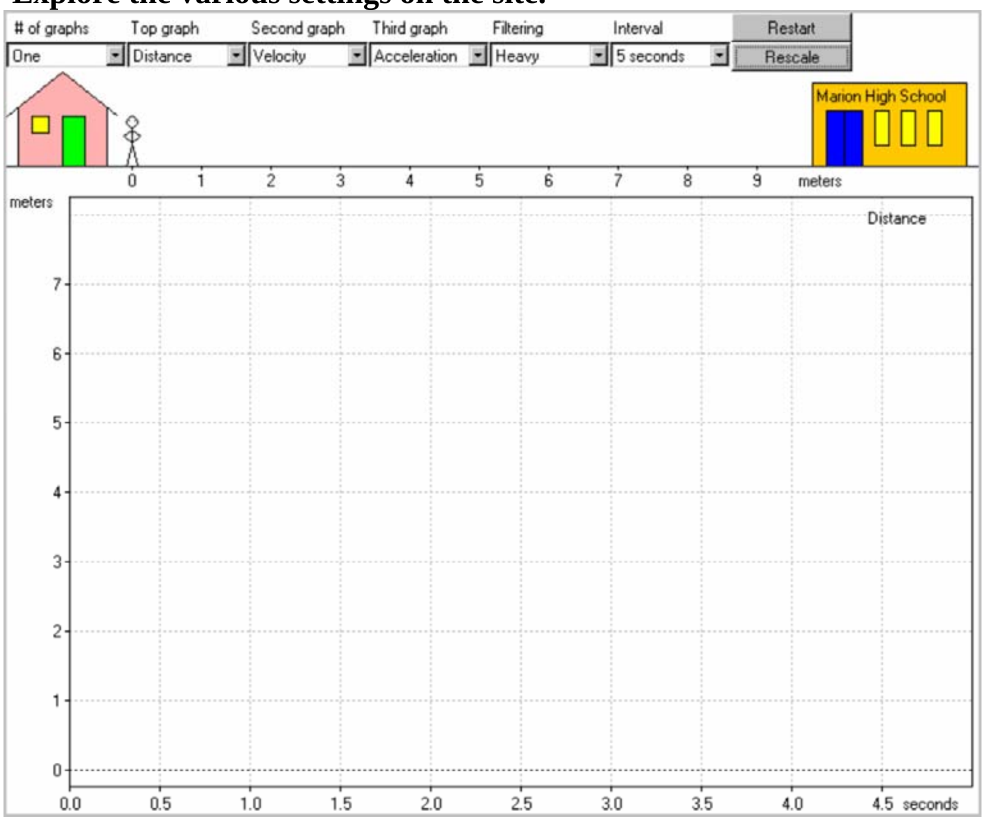
	Distance vs. Time	***Velocity vs. Time***	***Acceleration vs. Time***
Graph			
Equation	$d = -4.9t^2 + 10$	*The velocity is the first derivative of the distance vs. time function* $v = -9.8t$	*The acceleration is the second derivative of the distance vs. time function* $a = -9.8$
Explanation	*The graph is curved because the velocity* $v = \frac{d_1 - d_0}{t_1 - t_0}$ *is changing as time increases.*	*The graph is linear because the velocity is increasing at a constant rate. At time zero the velocity is zero. It becomes more negative as time increases. The slope is negative because the ball is moving toward the point of measurement (the ground).*	*The graph of the acceleration is constant because the ball is acted upon by the constant acceleration of gravity. It is negative because the ball is accelerating toward the point of measurement (the ground).*

Explore

Part 1

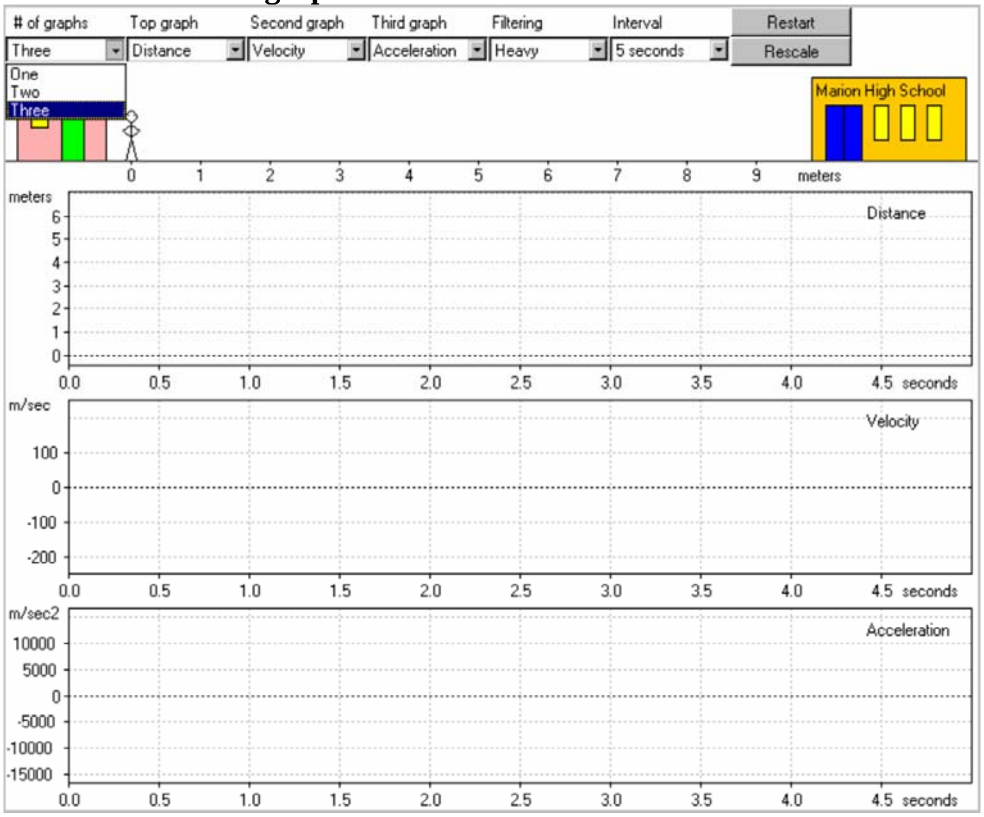
Arrange participants in groups of 2 – 4. Participants will need access to a computer and the Internet. The purpose of this exploration is to investigate, in very general terms, the relationship between the graphs of distance vs. time, velocity vs. time, and acceleration vs. time using a Java applet that simulates motion. Participants should describe the relationships in very general terms. Allow participants approximately 10 minutes to investigate the applet.

1. **Open the website http://www.mste.uiuc.edu/users/Murphy/MovingMan/MovingMan.html. Explore the various settings on the site.**

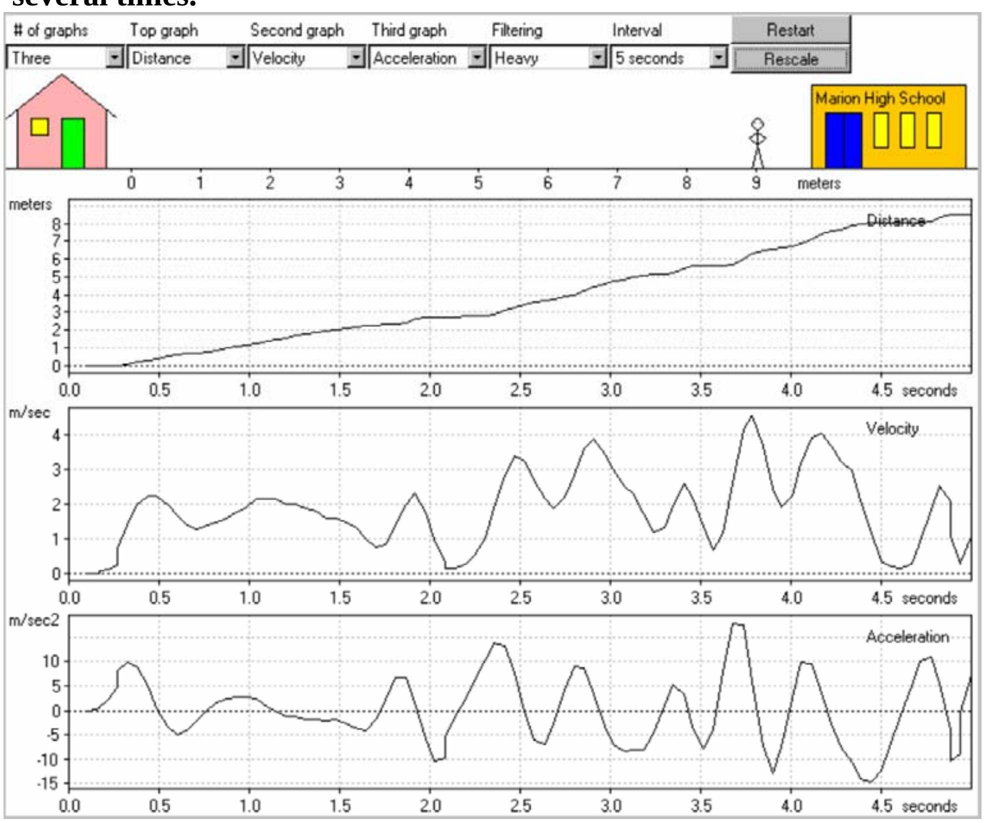


2. **How would you describe the information that can be explored on this website?**
   Graphical representations of distance vs. time, velocity vs. time, and acceleration vs. time can be explored over various time intervals.

3. Set the number of graphs to three and the interval to 5 seconds.



4. Drag the stick figure using your mouse. Try to drag the figure at a rate that gives a linear distance vs. time graph. Hit Rescale. You may have to restart several times.



5. **How can you use the graphs of the moving man to describe what is happening over a particular time interval? Use very general terms such as increasing, decreasing, steeper, flatter, stopped, faster, and slower in your description. Remember that the velocity is the change in the distance and that the acceleration is the change in the velocity.**
   Following is a possible response using the example in step 4.
   The distance increased by a very small amount in the first two seconds, and then increased by a larger amount in the interval between 2 and 3 seconds.
   The velocity during that interval increased from nearly 0 to a larger amount then had some smaller increases because the distance increased at a faster rate and decreases because the distance increased at a slower rate.
   The acceleration increases and decreases through positive and negative values because the velocity is increasing at a positive rate and decreasing at a negative rate over that interval.
   This question may prove challenging for participants. It is really an exercise in investigating rate of change over an interval by interpreting graphs, but the context of velocity and acceleration are complex.

Facilitation Questions:

- How would you describe the figure's movement when the velocity is negative?
  The figure is moving toward home. The distance is decreasing as time increases.
- How would you describe the figure's movement when the acceleration is 0?
  The distance is varying linearly with the time. The velocity is constant.

6. **Try to move the figure so that the distance vs. time graph curves upward. Hit Rescale. You may have to restart several times. How did you move the figure to accomplish a distance vs. time graph that curves upward?**
   Start at home, then drag the figure slowly, then speed up toward the school.

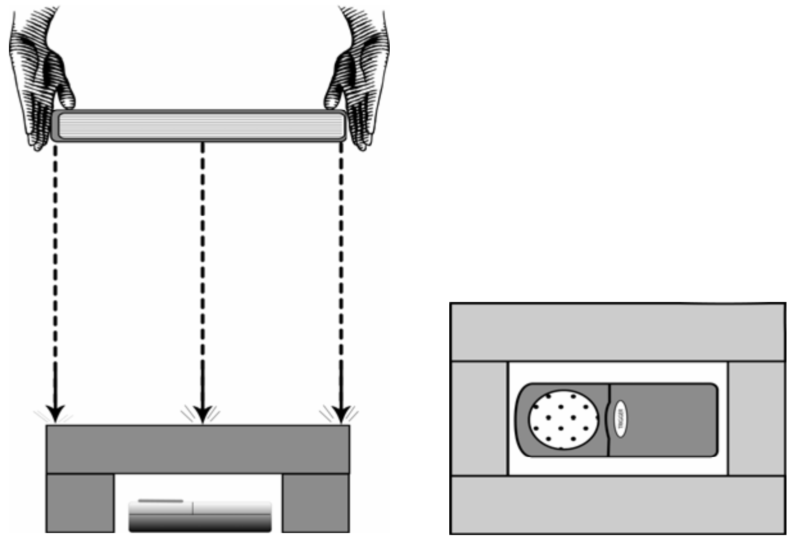
7. **How would you describe what is happening with the velocity vs. time and the acceleration vs. time graphs in the situation in question 6?**
   Possible responses will vary. In general the velocity vs. time graph will increase. The velocity vs. time graph will be linear where the velocity is increasing or decreasing at a constant rate. The graph will be curved where the velocity is increasing or decreasing at a changing rate. The acceleration vs. time graph is constant where the velocity vs. time graph is linear and is increasing or decreasing where the velocity vs. time graph is curved.

8. **Try to move the figure so that the distance vs. time graph curves downward. Hit Rescale. You may have to restart several times. How did you move the figure to accomplish a distance vs. time graph that curves downward?**
   Start at the school then drag the figure slowly then speed up toward home. Participants will have to drag the figure to the school then back. They will only look at the second half of the curve.

9. **How would you describe what is happening with the velocity vs. time and the acceleration vs. time graphs in the situation in question 8?**
Possible responses will vary. In general the velocity vs. time graph will increase. The velocity vs. time graph will be linear where the velocity is increasing or decreasing at a constant rate. The graph will be curved where the velocity is increasing or decreasing at a changing rate. The acceleration vs. time graph is constant where the velocity vs. time graph is linear and is increasing or decreasing where the velocity vs. time graph is curved.

Part 2

Point out the materials on the participants' tables. Demonstrate the use of a "cage" similar to the one in the picture to protect the CBR when an object is dropped on it. Instructions have been provided on how to build the "cage" if needed.



Participants should remain in the same group as the previous activity.
Ask the participants to begin the activity.

Examine the materials at your table. You will be using these items to investigate motion data using a CBR. See the Running the Ranger Program Technology Tutorial for assistance. Sort the items into three groups according to the table below. Write the description of the item and its motion in the appropriate column.

Motion that Yields Linear Relationships	Motion that Yields Nonlinear Relationships	Not Sure of the Relationship
Possible responses might include a battery powered car moving towards or away from the CBR or an action figure with parachute falling toward the CBR.	*Possible responses might include a large hard-bound book dropped on the CBR using the CBR roll cage or a ball rolled down a ramp toward the CBR.*	*Possible responses might include a coffee filter dropped on the CBR or a yo-yo used over the CBR.*

Facilitation Questions:

- Why did you group the items the way that you did?
  Possible responses might include prior experience, observing the object move, just guessed.
- Can some of the objects fit in more than one group? Which ones? Why or why not?
  Answers will vary. One example is a book being dropped on the CBR. The distance vs. time graph is quadratic, but the velocity vs. time graph is linear.

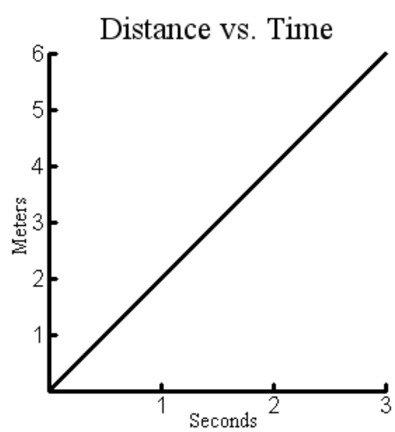
Part 3

1. **Refer to the table in Part 2. Choose one of the items out of the "Motion that Yields Linear Relationships" group. Design an experiment using the CBR to collect linear data using the item that you have chosen. Describe your experiment below. For assistance in using a CBR, refer to the CBR section of the Motion Technology Tutorial.**
   The battery-powered car will be directed away from the CBR. Data will be collected for 3 seconds.

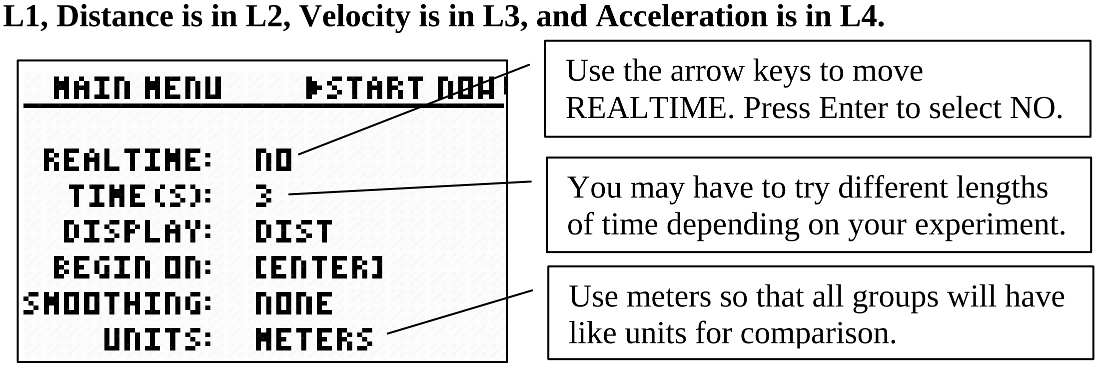
2. **What are the variables in your experiment?**
   Distance and time.

3. **Explain which variable is dependent and why and which variable is independent and why.**
   Distance is the dependent variable because it is measured at specific time intervals that are being controlled. Time is the independent variable because it is the variable that is being controlled.

4. **Sketch your prediction of what the graph in your experiment will look like in the space below.**



5. **Use the RANGER program in the APPS menu to collect the data. The settings on the calculator should be similar to the example shown below, but may be changed if necessary. Once the data is collected; press ON, ENTER, then GRAPH. This breaks the program and graphs the data. Time is in L1, Distance is in L2, Velocity is in L3, and Acceleration is in L4.**



6. Did your experiment yield the linear results you expected? If not, why not? If it did not, revise your experiment and restart Part 3.
Responses will vary.

7. What are the domain and range for the data you collected? (Don't forget about the units.)
The domain for this example is $0\,seconds \le time \le 3\,seconds$. *The range is* $0\,meters \le distance \le 1.5\,meters$.

8. How can the domain and range for the collected data be described in terms of the experiment?
The domain is the time from the beginning of the car's movement to the end of the car's movement. The range is the distance the car traveled.

9. How can you describe the rate of change in the data? (Don't forget about the units.)
The rate of change is $\frac{0.5\,meters}{1\,second}$.

10. Determine a function rule that can be used to model the collected data. Write the rule below.
The function rule is distance = 0.5(time) or y = 0.5x.

11. How can you justify that your function rule is a "good" model?
Graph the rule over a scatterplot of the data.

12. How are the domain and range for the function rule and the domain and range for collected data alike?
They both have the same units.

13. How are the domain and range for the function rule and the domain and range for collected data different?
The domain for the data is restricted to positive values. The domain for the function is all real numbers.

14. How can you find the value of the dependent variable when given a value of the independent variable?
Possible responses might include: trace along the graph, use the table feature, substitute into the equation and evaluate.

15. How can you find the value of the independent variable when given a value of the dependent variable?
Possible responses might include: trace along the graph, use the table feature, substitute into the equation and solve.

16. In what way does the collected data differ from your prediction?
The rate of change for the collected data is half the rate of change of the prediction.

17. If your students were working in groups on this experiment, what questions would you need to ask to facilitate the experiment?
Responses will vary.

18. Prepare a short word document using TI Connect to communicate to others the details of your experiment. For assistance, refer to the TI Connect section of the Motion Technology Tutorial.

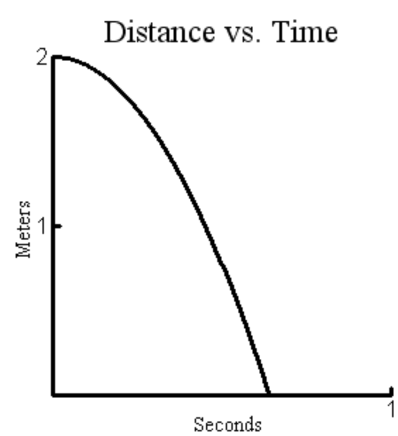
Part 4

1. **Refer to the table in Part 2. Choose one of the items out of the "Motion that Yields Quadratic Relationships" group. Design an experiment using the CBR to collect quadratic data using the item that you have chosen. Describe your experiment below. For assistance in using a CBR, refer to the CBR section of the Motion Technology Tutorial.**
   The basketball will be dropped on the CBR using the CBR roll cage. The data will be collected for 1 second.

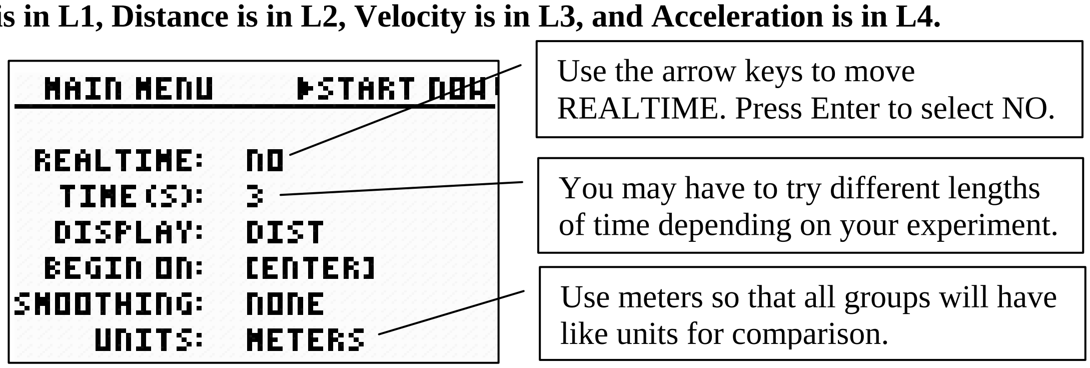
2. **What are the variables in your experiment?**
   Distance and time

3. **Explain which variable is dependent and why and which variable is independent and why.**
   Distance is the dependent variable because it is measured at specific time intervals that are being controlled. Time is the independent variable because it is the variable that is being manipulated.

4. **Sketch your prediction of what the graph in your experiment will look like in the space below.**



5. **Use the RANGER program in the APPS menu to collect the data.**
   The settings on the calculator should be similar to the example shown below, but may be changed if necessary. Once the data is collected; press [ON], [ENTER], and then [GRAPH]. This breaks the program and graphs the data. Time is in L1, Distance is in L2, Velocity is in L3, and Acceleration is in L4.



6. **Did your experiment yield the quadratic results you expected? If not, why not? If it did not, revise your experiment and restart Part 3.**
   Responses will vary.

7. **What are the domain and range for the data you collected? (Don't forget about the units.)**
   The domain for this example is $0 \text{ seconds} \le time \le 0.64 \text{ seconds}$. *The range is* $0 \text{ meters} \le distance \le 2 \text{ meters}$.

8. **How can the domain and range for the collected data be described in terms of the experiment?**
   The domain is the time from the beginning of the ball's drop to the end of the ball's drop. The range is the distance the ball fell.

9. **How can you describe the rate of change in the data? (Don't forget about the units.)**
   The rate of change is changing.

10. **Determine a function rule that can be used to model the collected data. Write the rule below.**
    The function rule is $distance = -4.9(time)^2 + 2$ *or* $y = -4.9(x)^2 + 2$.

11. **How can you justify that your function rule is a "good" model?**
    Graph the rule over a scatterplot of the data.

12. **How are the domain and range for the function rule and the domain and range for collected data alike?**
    They both have the same units.

13. **How are the domain and range for the function rule and the domain and range for collected data different?**
    The domain and range for the data is restricted to positive values. The domain for the function is all real numbers. The range of the function is all real numbers less than 2.

14. **How can you find the value of the dependent variable when given a value of the independent variable? Describe a method different than the method you described in Part 3.**
    Possible responses might include: trace along the graph, use the table feature, substitute into the equation and evaluate.

15. How can you find the value of the independent variable when given a value of the dependent variable? Describe a method different than the method you described in Part 3.
Possible responses might include: trace along the graph, use the table feature, substitute in to the equation and solve.

16. In what way does the collected data differ from your prediction?
The prediction was accurate.

17. If your students were working in groups on this experiment, what questions would you need to ask to facilitate the experiment?
Responses will vary.

18. Prepare a short word document using TI Connect to communicate to others the details of your experiment. For assistance, refer to the TI Connect section of the Motion Technology Tutorial.

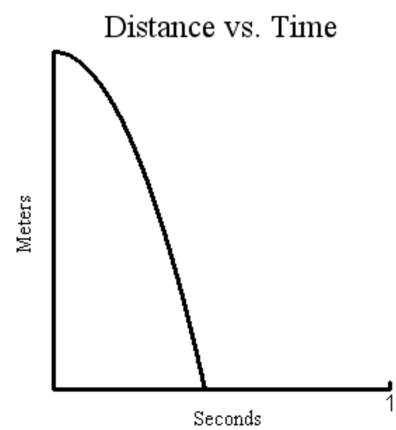
Part 5

1. **Refer to the table in Part 2. Choose one of the items out of the "Not Sure of the Relationship" group. Design an experiment using the CBR to collect data using the item that you have chosen. Describe your experiment below. For assistance in using a CBR, refer to the CBR section of the Motion Technology Tutorial.**
   The coffee filter will be dropped on the CBR. Data will be collected for approximately 1 second.

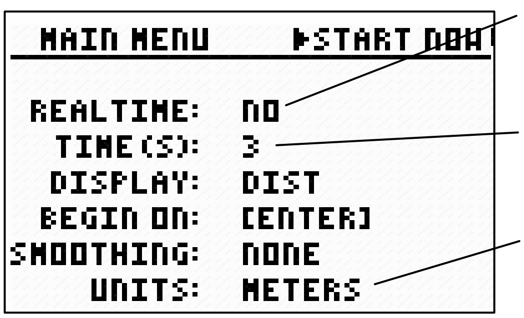
2. **What are the variables in your experiment?**
   Distance and time

3. **Explain which variable is dependent and why and which variable is independent and why.**
   Distance is the dependent variable because it is measured at specific time intervals that are being controlled. Time is the independent variable because it is the variable that is being manipulated.

4. **Sketch your prediction of what the graph in your experiment will look like in the space below.**



5. **Use the RANGER program in the APPS menu to collect the data. The settings on the calculator should be similar to the example shown below, but may be changed if necessary. Once the data is collected; press ON, ENTER, and then GRAPH. This breaks the program and graphs the data. Time is in L1, Distance is in L2, Velocity is in L3, and Acceleration is in L4.**

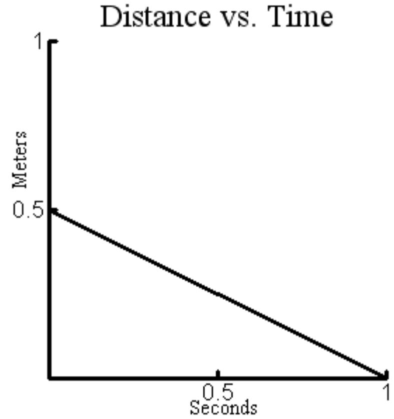


Use the arrow keys to move REALTIME. Press Enter to select NO.

You may have to try different lengths of time depending on your experiment.

Use meters so that all groups will have like units for comparison.

6. **Did your experiment yield the results you predicted? If not, why not?**



No, expected it to be a quadratic relationship and it was linear. Air resistance had an effect.

7. **What are the domain and range for the data you collected? (Don't forget about the units.)**
The domain for this example is $0\,seconds \le time \le 1\,second$ *, the range is* $0\,meters \le distance \le 0.5\,meters$.

8. **How can the domain and range for the collected data be described in terms of the experiment?**
The domain is the time from the beginning of the filter's drop to the end of the filter's drop. The range is the distance the filter fell.

9. **How can you describe the rate of change in the data? (Don't forget about the units.)**
The rate of change is $-\frac{0.5\,meters}{1\,second}$.

10. **Determine a function rule that can be used to model the collected data. Write the rule below.**
The function rule is $distance = -\frac{0.5\,meters}{1\,second}(time) + 0.5$ *or* $y = -0.5(x) + 0.5$.

11. **How can you justify that your function rule is a "good" model?**
Graph the rule over a scatterplot of the data.

12. **How are the domain and range for the function rule and the domain and range for collected data alike?**
They both have the same units.

13. **How are the domain and range for the function rule and the domain and range for collected data different?**
The domain and range for the data is restricted to positive values. The domain for the function is all real numbers. The range of the function is all real numbers less than 2.

14. **How can you find the value of the dependent variable when given a value of the independent variable? Describe a method different than the methods you described in Parts 3 and 4.**
Possible responses might include: trace along the graph, use the table feature, substitute into the equation and evaluate.

15. **How can you find the value of the independent variable when given a value of the dependent variable? Describe a method different than the methods you described in Parts 3 and 4.**
Possible responses might include: trace along the graph, use the table feature, substitute into the equation and solve.

16. **In what way does the collected data differ from your prediction?**
The prediction was accurate.

17. **If your students were working in groups on this experiment what questions would you need to ask to facilitate the experiment?**
Responses will vary.

18. **Prepare a short word document using TI Connect to communicate to others the details of your experiment. For assistance, refer to the TI Connect section of the Motion Technology Tutorial.**

Explain

Pose the following questions and tasks to participants once they have completed their experiments. This is designed as a whole group activity.

1. What are the benefits of using this type of technology with students?
   Possible responses might include; facilitates active student engagement and make real world connections to abstract concepts.

2. What are the hindrances to using this type of technology with students?
   Possible responses might include: availability of technology, classroom management, and time.

3. Why did you choose the items you used in your experiments?
   Answers will vary. Ask participants to explain why.

4. What factors would you have to control to compare motion in different experiments?
   Possible responses might include the units of measurement.

5. In what ways would you describe the mathematics utilized in the previous experiments?
   Possible responses might include: linear functions, quadratic functions, etc.

6. Ask groups to share one of the documents that explains their experiments with the whole group. This can be done either through a computer gallery tour or saving the document to a jump drive and projecting from the presentation computer.

Motion - Intentional Use of Data

1. *At the close of Motion, distribute the Intentional Use of Data activity sheet to each participant.*

TEKS	*A sample of some of the TEKS addressed is given.* *A.5(A) Determine whether or not given situations can be represented by linear functions.* *A.5(B) Determine the domain and range values for which linear functions make sense for given situations.* *A.5(C) Use, translate, and make connections among algebraic, tabular, graphical, or verbal descriptions of linear functions.*	
Question(s) to Pose to Students	*Why does the domain and range for the situation differ from the domain and range for the function?*	
Cognitive Rigor	Knowledge	*Identifying variables*
	Understanding	*Describe the type of data that you would use.*
	Application	*Calculate the range when given the domain.*
	Analysis	*Explain the concept of slope as rate of change.*
	Creation	*Develop the concept of slope as rate of change by graphing.*
	Evaluation	*Interpret the meaning of slope and intercepts.*
Data Source(s)	Real-Time	*Data from the CBR, data generated from the web applet*
	Archival	
	Categorical	
	Numerical	*Distance vs. Time, Velocity vs. Time, Acceleration vs. Time*
Setting	Computer Lab	*Students could explore the data site and data in small groups.*
	Mini-Lab	*Students could collect the data, then return to group and analyze the data.*
	One Computer	*Whole class exploration, teacher downloads data to students.*
	Graphing Calculator	*Teacher enters the data, sends the data to student calculators, and discusses the situation.*
	Measurement Based Data	*Students conduct measurement experiments to gather data.*
Bridge to the Classroom	*CBRs and calculators*	

2. *Prompt the participants to work in pairs to identify those TEKS that received greatest emphasis during this activity. Prompt the participants to also identify two key questions that were emphasized during this activity. Allow four minutes for discussion.*

Facilitation Questions

- Which mathematical TEKS formed the primary focus of this activity?
  A.5(A) Determine whether or not given situations can be represented by linear functions.
  A.5(B) Determine the domain and range values for which linear functions make sense for given situations.
  A.6(A) Develop the concept of slope as rate of change and determine slopes from graphs, tables, and algebraic representations.
- What additional math TEKS supported the primary TEKS?
  A.6(B) Interpret the meaning of slope and intercepts in situations using data, symbolic representations, or graphs.
  A.6(C) Investigate, describe, and predict the effects of changes in m and b on the graph of $y = mx + b$.
  A.6(F) Interpret and predict the effects of changing slope and y-intercept in applied situations.
- How do these TEKS translate into guiding questions to facilitate student exploration of the content?
  The questions provide a guide to direct participants to discover what is being taught through exploration.
- How do the questions reflect the depth and complexity of the TEKS?
  The questions are written at the higher levels of Bloom's taxonomy to help the participants do more in-depth thinking in order to gain a deeper understanding of the content.
- How do the questions support the use of technology?
  The questions are used to guide the students through technology exploration not tell the participants what they should be doing or how they should doing it.

3. *As a whole group, share responses for two to three minutes.*

4. *As a whole group, identify the level(s) of rigor (based on Bloom's taxonomy) addressed, the types of data, the setting, and the data sources used during this activity. Allow three minutes for discussion.*

Facilitation Questions

- What attributes of the activity support the level of rigor that you identified?
  Students have to create their own experiment, generate and analyze their own data.

5. *As a whole group, discuss how this activity might be implemented in other settings. Allow five minutes for discussion.*

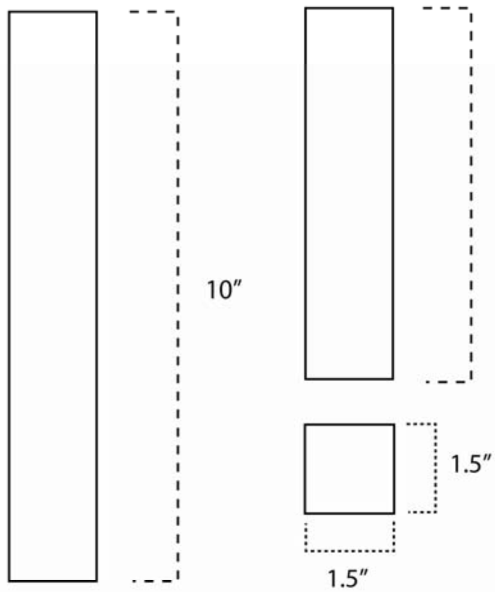
Facilitation Questions

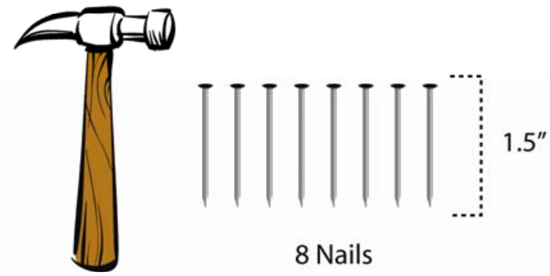
- How would this activity change if there were only access to one computer (one graphing calculator, CBR, etc.) per participant?
  This would allow for more exploration. There would be more opportunities for actual data collection. Once collected each participant would have the opportunity to work with technology.
- How would this activity change if there were only access to one computer (one graphing calculator, CBR, etc.) per small group of participants?
  This would be a good setting because each participant would get an opportunity to work with collecting the data.
- How would this activity change if there were only access to one computer (one graphing calculator, CBR, etc.) for the entire group of participants?
  This type of setting would still work for participants. The facilitator could create small groups and have them use the materials to conduct their experiment while the other groups observe and/or record the data for later use.
- How does technology enhance learning?
  The technology helps to make the data collection more relevant and allows more opportunities for in-depth thinking.

6. *Prompt the participants to set aside the completed Intentional Use of Data activity sheet for later discussion. These completed activity sheets will be used during the Elaborate phase as prompts for generating attributes of judicious users of technology.*

CBR Roll Cage

Figure 1





Directions

1) Gather the materials together shown in Figure 1.

2) Place the two 6″ pieces of wood parallel to each other 10″ apart.

3) Place the two 10″ pieces of wood perpendicular and parallel on top of the first two lining up the ends forming a square.

4) Nail two nails in each end to secure the pieces together as in Figure 2.

When finished, the apparatus should appear as in Figure 3.

Figure 3 - Top

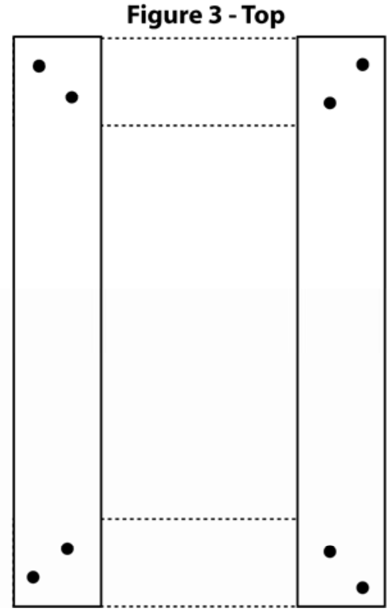
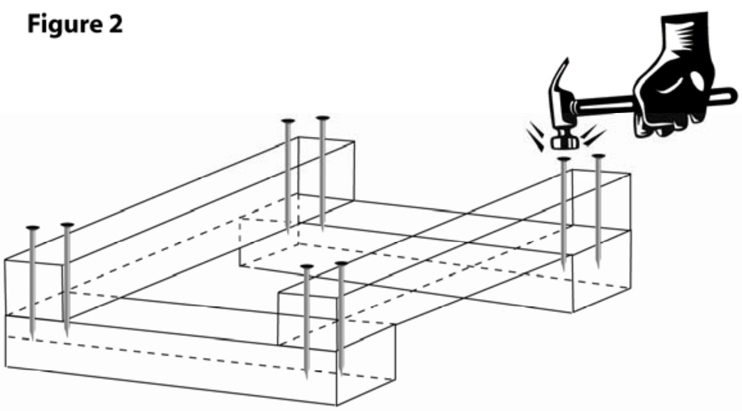


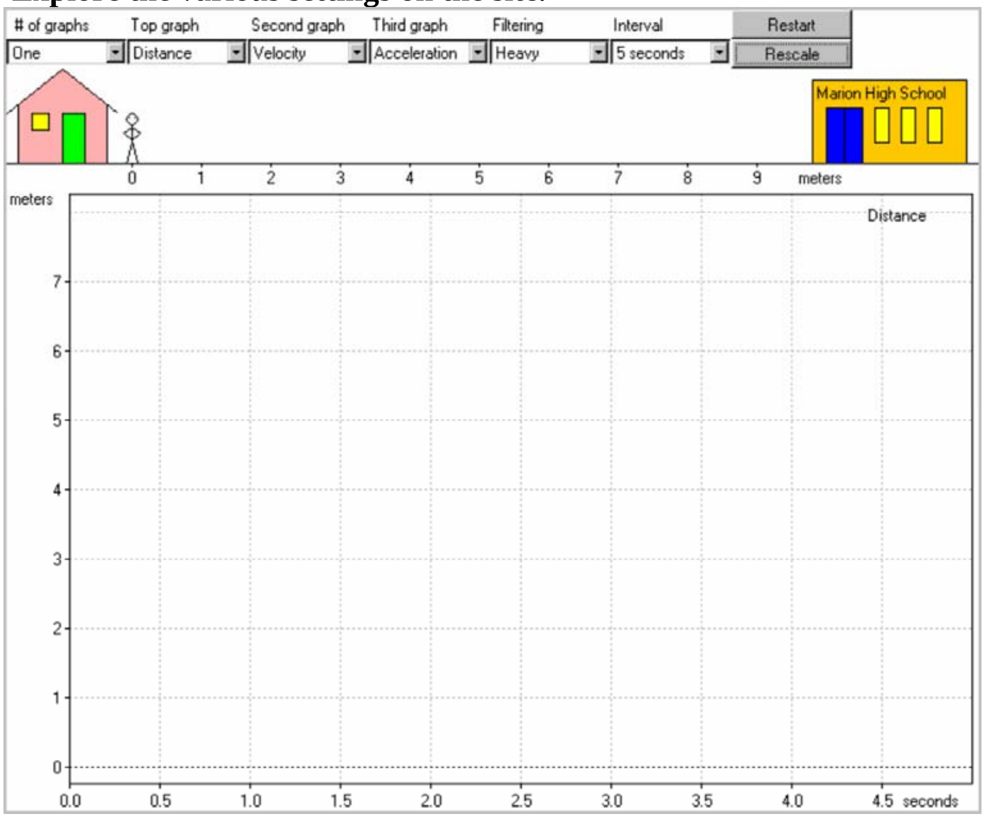
Figure 2



Activity Sheet: Motion

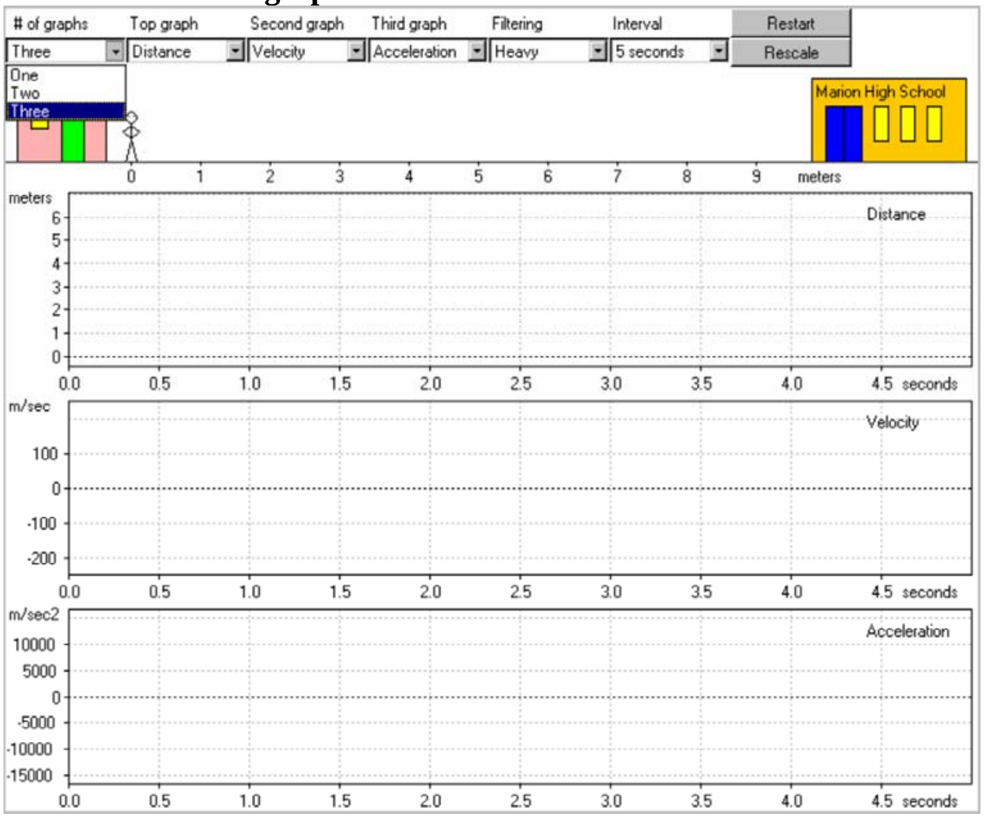
Part 1

1. **Open the website**
   http://www.mste.uiuc.edu/users/Murphy/MovingMan/MovingMan.html.
   Explore the various settings on the site.

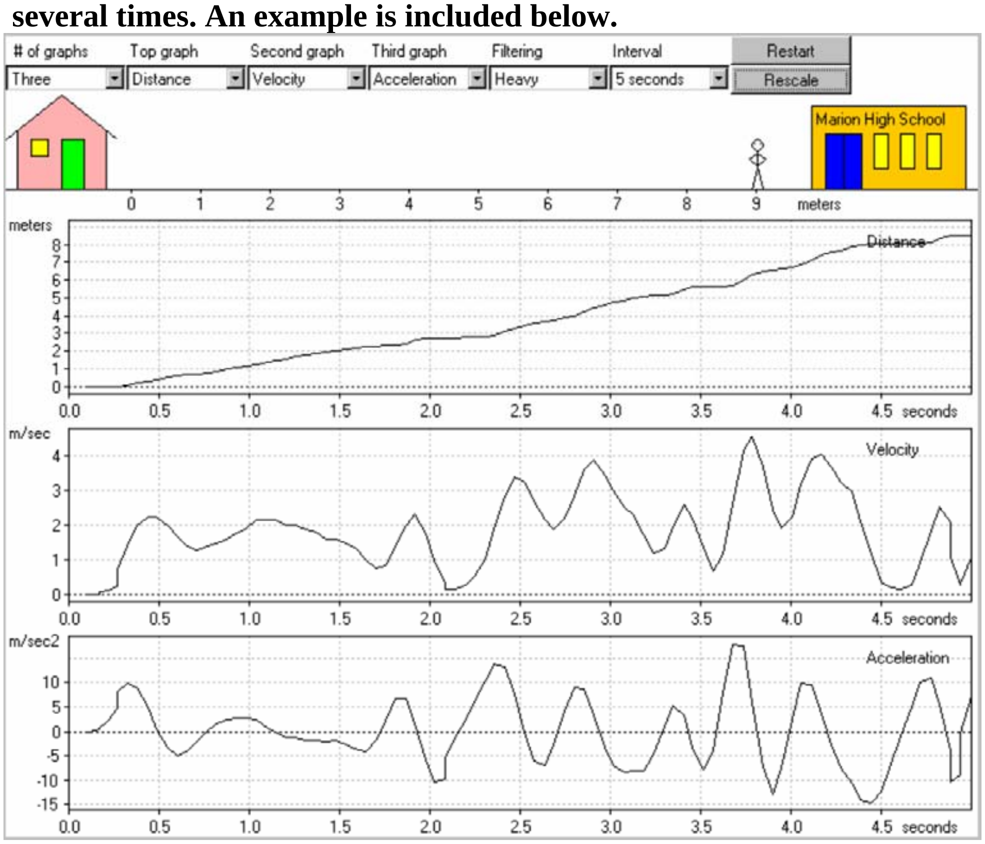


2. **How would you describe the information that can be explored on this website?**

3. Set the number of graphs to three and the interval to 5 seconds.



4. Drag the stick figure using your mouse. Try to drag the figure at a rate that gives a linear distance vs. time graph. Hit Rescale. You may have to restart several times. An example is included below.



5. **How can you use the graphs of the moving man to describe what is happening over a particular time interval? Use very general terms such as increasing, decreasing, steeper, flatter, stopped, faster, and slower in your description. Remember that the velocity is the change in the distance and that the acceleration is the change in the velocity.**

6. **Try to move the figure so that the distance vs. time graph curves upward. Hit Rescale. You may have to restart several times. How did you move the figure to accomplish a distance vs. time graph that curves upward?**

7. **How would you describe what is happening with the velocity vs. time and the acceleration vs. time graphs in the situation in question 6?**

8. **Try to move the figure so that the distance vs. time graph curves downward. Hit Rescale. You may have to restart several times. How did you move the figure to accomplish a distance vs. time graph that curves downward?**

9. **How would you describe what is happening with the velocity vs. time and acceleration vs. time graphs in the situation in question 8?**

Part 2

Examine the materials at your table. You will be using these items to investigate motion data using a CBR. See the Running the Ranger Program Technology Tutorial for assistance. Sort the items into three groups according to the table below. Write the description of the item and its motion in the appropriate column.

Motion that Yields Linear Relationships	Motion that Yields Nonlinear Relationships	Not Sure of the Relationship

Part 3

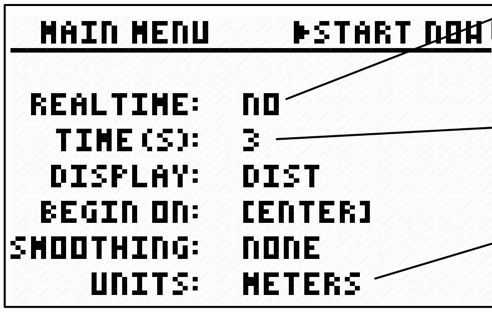
1. **Refer to the table in Part 2. Choose one of the items out of the "Motion that Yields Linear Relationships" group. Design an experiment using the CBR to collect linear data using the item that you have chosen. Describe your experiment below. For assistance in using a CBR, refer to the CBR section of the Motion Technology Tutorial.**

2. **What are the variables in your experiment?**

3. **Explain which variable is dependent and why and which variable is independent and why.**

4. **Sketch your prediction of what the graph in your experiment will look like in the space below.**

5. **Use the RANGER program in the APPS menu to collect the data. The settings on the calculator should be similar to the example shown below, but may be changed if necessary. Once the data is collected; press [ON], [ENTER], and then [GRAPH]. This breaks the program and graphs the data. Time is in L1, Distance is in L2, Velocity is in L3, and Acceleration is in L4.**



Use the arrow keys to move REALTIME. Press Enter to select NO.

You may have to try different lengths of time depending on your experiment.

Use meters so that all groups will have like units for comparison.

6. **Did your experiment yield the linear results you expected? If not, why not? If it did not, revise your experiment and restart Part 3.**

7. **What are the domain and range for the data you collected? (Don't forget about the units.)**

8. How can the domain and range for the collected data be described in terms of the experiment?

9. How can you describe the rate of change in the data? (Don't forget about the units.)

10. Determine a function rule that can be used to model the collected data. Write the rule below.

11. How can you justify that your function rule is a "good" model?

12. How are the domain and range for the function rule and the domain and range for collected data alike?

13. How are the domain and range for the function rule and the domain and range for collected data different?

14. How can you find the value of the dependent variable when given a value of the independent variable?

15. How can you find the value of the independent variable when given a value of the dependent variable?

16. In what way does the collected data differ from your prediction?

17. If your students were working in groups on this experiment what questions would you need to ask to facilitate the experiment?

18. Prepare a short word document using TI Connect to communicate to others the details of your experiment. For assistance, refer to the TI Connect section of the Motion Technology Tutorial.

Part 4

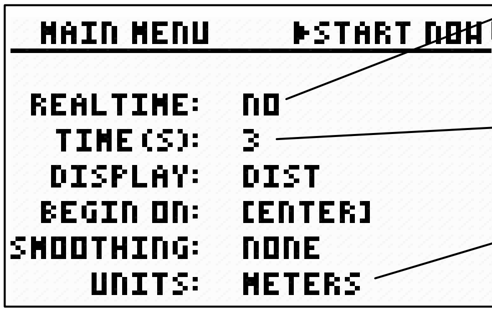
1. **Refer to the table in Part 2. Choose one of the items out of the "Motion that Yields Quadratic Relationships" group. Design an experiment using the CBR to collect quadratic data using the item that you have chosen. Describe your experiment below. For assistance in using a CBR, refer to the CBR section of the Motion Technology Tutorial.**

2. **What are the variables in your experiment?**

3. **Explain which variable is dependent and why and which variable is independent and why.**

4. **Sketch your prediction of what the graph in your experiment will look like in the space below.**

5. **Use the RANGER program in the APPS menu to collect the data. The settings on the calculator should be similar to the example shown below, but may be changed if necessary. Once the data is collected; press [ON], [ENTER], and then [GRAPH]. This breaks the program and graphs the data. Time is in L1, Distance is in L2, Velocity is in L3, and Acceleration is in L4.**



Use the arrow keys to move REALTIME. Press Enter to select NO.

You may have to try different lengths of time depending on your experiment.

Use meters so that all groups will have like units for comparison.

6. **Did your experiment yield the quadratic results you expected? If not, why not? If it did not, revise your experiment and restart Part 3.**

7. **What are the domain and range for the data you collected? (Don't forget about the units.)**

8. **How can the domain and range for the collected data be described in terms of the experiment?**

9. **How can you describe the rate of change in the data? (Don't forget about the units.)**

10. **Determine a function rule that can be used to model the collected data. Write the rule below.**

11. **How can you justify that your function rule is a "good" model?**

12. **How are the domain and range for the function rule and the domain and range for collected data alike?**

13. How are the domain and range for the function rule and the domain and range for collected data different?

14. How can you find the value of the dependent variable when given a value of the independent variable? Describe a method different than the method you described in Part 3.

15. How can you find the value of the independent variable when given a value of the dependent variable? Describe a method different than the method you described in Part 3.

16. In what way does the collected data differ from your prediction?

17. If your students were working in groups on this experiment what questions would you need to ask to facilitate the experiment?

18. Prepare a short word document using TI Connect to communicate to others the details of your experiment. For assistance, refer to the TI Connect section of the Motion Technology Tutorial.

Part 5

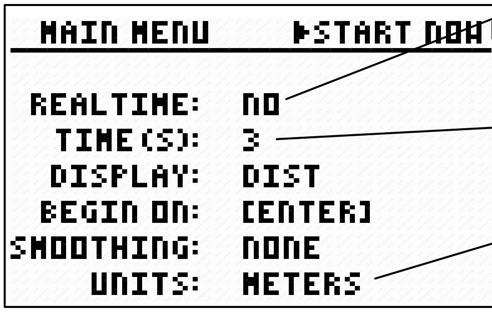
1. **Refer to the table in Part 2. Choose one of the items out of the "Not Sure of the Relationship" group. Design an experiment using the CBR to collect data using the item that you have chosen. Describe your experiment below. For assistance in using a CBR, refer to the CBR section of the Motion Technology Tutorial.**

2. **What are the variables in your experiment?**

3. **Explain which variable is dependent and why and which variable is independent and why.**

4. **Sketch your prediction of what the graph in your experiment will look like in the space below.**

5. **Use the RANGER program in the APPS menu to collect the data. The settings on the calculator should be similar to the example shown below, but may be changed if necessary. Once the data is collected; press [ON], [ENTER], and then [GRAPH]. This breaks the program and graphs the data. Time is in L1, Distance is in L2, Velocity is in L3, and Acceleration is in L4.**



Use the arrow keys to move REALTIME. Press Enter to select NO.

You may have to try different lengths of time depending on your experiment.

Use meters so that all groups will have like units for comparison.

6. **Did your experiment yield the results you predicted? If not, why not?**

7. **What are the domain and range for the data you collected? (Don't forget about the units.)**

8. **How can the domain and range for the collected data be described in terms of the experiment?**

9. How can you describe the rate of change in the data? (Don't forget about the units.)

10. Determine a function rule that can be used to model the collected data. Write the rule below.

11. How can you justify that your function rule is a "good" model?

12. How are the domain and range for the function rule and the domain and range for collected data alike?

13. How are the domain and range for the function rule and the domain and range for collected data different?

14. How can you find the value of the dependent variable when given a value of the independent variable? Describe a method different than the methods you described in Parts 3 and 4.

15. How can you find the value of the independent variable when given a value of the dependent variable? Describe a method different than the methods you described in Parts 3 and 4.

16. In what way does the collected data differ from your prediction?

17. If your students were working in groups on this experiment what questions would you need to ask to facilitate the experiment?

18. Prepare a short word document using TI Connect to communicate to others the details of your experiment. For assistance, refer to the TI Connect section of the Motion Technology Tutorial.

Motion - Intentional Use of Data

TEKS		
Question(s) to Pose to Students		
Cognitive Rigor	Knowledge	
	Understanding	
	Application	
	Analysis	
	Evaluation	
	Creation	
Data Source(s)	Real-Time	
	Archival	
	Categorical	
	Numerical	
Setting	Computer Lab	
	Mini-Lab	
	One Computer	
	Graphing Calculator	
	Measurement Based Data	
Bridge to the Classroom		