Speed Demons: Math and Science in Motion

Grade Level or Special Area: 8th grade Math / Science
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Length of Unit: 5 lessons

I. ABSTRACT

This unit combines math and science to teach in-depth lessons on graphing using real time technology. We believe graphing is an extremely important skill that all students should possess! Technology will be integrated into the lessons by using graphing calculators (TI-83 Plus), calculator based labs (CBL-2), motion detectors (CBR), and computer software. Students will progress through many stages of graphing. They will create paper graphs manually, plot points on a distance-time graph, stand as coordinates as a human graph, match pre-made motion graphs using various materials, and test the angle of inclination's affect on speed. Math and science integrate beautifully in this extremely fun set of lessons.

II. OVERVIEW

A. Concept Objectives
   1. Students will develop an understanding of basic graphing concepts such as slope, x-intercept, y-intercept, t-charts, and linear equations
   2. Students will interpret graph meaning
   3. Students will develop an understanding of how the TI-83 Plus, CBL2, and CBR work together to electronically graph
   4. Students will develop an understanding of how their kinesthetic motion relates to time on a graph

B. Content from the *Core Knowledge Sequence*
   1. Math 8th grade
      a. Organization and Presentation of Linear Data
         i. Linear Applications and Proportionality
            a) Concept of slope as rise over run
            b) Situations of proportionality can be translated into equations of the form y = mx + b, where m is the constant slope and intercepts
            c) Situations of constant proportionality can be shown as a line on the coordinate plane
            d) Functions and equations of a linear function can be determined given the slope and y-intercept
            e) Equations of a linear function can be determined from data in a table
            f) Values read from the graph of a linear function from data in a table
            g) Frequencies calculated from data
            h) Charts, graphs, and tables indicating frequencies
   2. Science 8th grade
      a. Electricity and Magnetism
         i. Electricity
            a) Basic terms and concepts (review from grade 4):
            b) Electricity is the flow of electrons in a conductor
            c) Opposite charges attract, like charges repel
            d) Conductors and insulators
            e) Open and closed circuits
            f) Electrical safety

ii. Electricity as the flow of electrons
a) Conductors: materials like metals that easily give up electrons

3. Science 6th grade
a. Speed
i. Speed = how far something travels in a unit of time
a) Formula: speed = distance / time (S=D/T)
b) Familiar units for measuring speed: miles or kilometers per hour

ii. Heat
a) Heat and temperature is how vigorously atoms are moving and colliding

C. Skill Objectives
1. Label axes of a graph
2. Plot ordered pairs
3. Determine slope
4. Determine y-intercept
5. Put equations in the form y=mx+b
6. Recognize independent and dependent variables
7. Determine if a graph is linear
8. Graph a line
9. Graph from a t-chart
10. Graph from a word problem
11. Answer questions from a graph
12. Be a coordinate in a human graph
13. Verbalize graph situations
14. Match graphs to their written descriptions
15. Be able to use a CBL2 in order to collect data to produce a graph
16. Be able to use a TI-83 Plus calculator to graph information from a CBL2
17. Be able to use a CBR to graph motion
18. Use a TI-83 Plus, CBL2, CBR to form graphs
19. Match overhead graphs
20. Match calculator produced graphs
21. Peer evaluate partners
22. Write a summary of the day's experience
23. Make predictions before seeing graphs
24. Work with a group to use TI-83 Plus, CBR, CBL2 to collect data
25. Manually transfer graph from calculator to paper
26. Make t-charts from graphs
27. Compare/contrast different graphs

III. BACKGROUND KNOWLEDGE

A. For Teachers : See resource list

B. For Students : Graphing equations
1. Coordinate plane
2. Ordered pairs
3. X-axis
4. Y-axis
5. Quadrants
6. Slope
7. Y-intercept
8. Linear equation

9. Independent variable
10. Dependent variable
11. T-chart (table)
12. Linear graph
13. Function

IV. RESOURCES

A. Materials
1. Oversized graph post it note paper
2. Sticky dots
3. TI CBL-2s
4. CBRs
5. TI-83+ calculators
6. TI resource CD
7. Overhead projector
8. AA and AAA batteries
9. Appendices

B. Books
1. Voltz, Donald L. and Sapatka, Sandy, Middle School Science with Calculators. Beaverton, OR: Vernier Software and Technology, 2000. ISBN # 1-929075-08-1
2. Larson, Roland E. et al, Heath Algebra 1: An Integrated Approach. Evanston, IL: McDougal Littell, 1998. ISBN # 0-669-45259-9
3. Boyd, Cindy J, Glencoe Algebra 1. New York: McGraw Hill, 1998. ISBN # 0-02-825327-2
4. TI-83 Plus Graphing Calculator Guide Book. Texas Instruments. (Accompanies purchase of TI-83 Plus Calculator).
5. Getting Started with CBL 2. Texas Instruments. (Accompanies purchase of CBL).

C. Websites
1. http://www.vernier.com/
2. http://education.ti.com/us/product/main.html
3. http://www2.vernier.com/free/CBL-Easy.pdf
4. http://www.vernier.com/mbl/comparison.html
5. http://education.ti.com/downloads/guidebooks/eng/cbl2-eng.pdf
6. http://education.ti.com/downloads/guidebooks/eng/cbr-eng.pdf

V. LESSONS

Lesson One: What's Your Graphing IQ?

A. *Daily Objectives*
1. Concept Objective(s)
   a. Students will develop an understanding of basic graphing concepts such as slope, x-intercept, y-intercept, t-charts, and linear equations
2. Lesson Content
   a. Basic review of graphing
   b. Initial assessment
3. Skill Objective(s)
   a. Label axes of a graph
   b. Plot ordered pairs
   c. Determine slope
   d. Determine y-intercept
   e. Put equations in the form y=mx+b
   f. Recognize independent and dependent variables

g. Determine if a graph is linear
h. Graph a line
i. Graph from a t-chart
j. Graph from a word problem
k. Answer questions from a graph

B. *Materials*
1. Sticky graph paper
2. Sticky dots
3. Ordered pair cards from *Suggested Points* (Appendix A)
4. *Student Directions for Sticky-Dot Activity* (Appendix B)
5. *Graphing on a Coordinate Plane* overhead (Appendix C)
6. *Graphing Questions* handout (Appendix D)
7. Markers (at least 3 colors per group)
8. Rulers

C. *Key Vocabulary*
1. Coordinate plane – the plane containing the x- and y- axes
2. Ordered pairs- pairs of numbers used to locate points in the coordinate grid, (x,y)
3. X-axis- the horizontal number line
4. Y-axis-the vertical number line
5. Quadrants-the four regions into which the x- and y- axes separate the coordinate plane
6. Slope – the ratio of the rise to the run as you move from one point to another along a line
7. Y-intercept- the coordinate at which a graph intersects the y-axes
8. Linear equation- an equation whose graph is a line
9. Independent variable – the variable in a function whose value is subject to choice, it affects the value of the dependent variable
10. Dependent variable- the variable in a function whose value is determined by the independent variable
11. T-chart (table)- a table that is used to show the x and y coordinates of a line
12. Linear graph- formed from an equation whose graph is a line
13. Function- a relationship between input and output in which the output depends on the input, a relation in which each element of the domain is paired with exactly one element of the range

D. *Procedures/Activities*
1. Prepare tables before lesson for groups of 4-5 students by having ready the following materials for group work: sticky graph paper, sticky dots, *Student Directions for Sticky-Dot Activity*, markers (at least 3 colors per group), and rulers.
2. Pass out one ordered pair card to each student as he/she enters. (Appendix A)
3. Have students read directions and begin activity.
4. Monitor graphing activity.
5. Lead a class-discussion about the groups' answers and results.
6. Use the *Graphing on a Coordinate Plane* overhead (Appendix C) to quickly review graphing concepts and vocabulary.
7. Summarize the graphing activity and reviewed concepts.

E. *Assessment/Evaluation*
1. *Graphing Questions* handout (Appendix D)
2. Teacher observation

Lesson Two: Graphing Situations

A. *Daily Objectives*

1. Concept Objective(s)
    a. Students will interpret graph meaning
2. Lesson Content
    a. Graphing to match various situations
    b. Graphing explained and interpreted in words
3. Skill Objective(s)
    a. Be a coordinate in a human graph
    b. Verbalize graph situations
    c. Match graphs to their written descriptions

B. Materials

1. Masking tape
2. Tags to label axes of floor graph (see Appendix E)
3. *Human Graph* ordered pairs (Appendix E)
4. *Situation/Graph Matching* cards (Appendix F)
5. *Assessment for Matching Graphs and Situations* (Appendix G)

C. Key Vocabulary

1. All vocabulary from lesson one
2. Distance/time graph- a graph showing the relationship between time and distance in a given situation
3. Time/temperature graph- a graph showing the relationship between time and temperature in a given situation
4. Speed – how fast something is moving; the path distance moved per time

D. Procedures/Activities

1. Mark x and y axis (quadrant I only) on the floor of a cleared space in the classroom prior to class.
2. Copy, cut and laminate one set of matching cards (Appendix F) for each group.
3. When the lesson begins, assign ordered pairs for human graph (Appendix E)
4. Have students place themselves on a room sized graph and sit down on their ordered pair.
5. Once the graph is made, describe the situation and label the x- and y- axes.
6. Lead students in a discussion about aspects of the graph (Appendix E) Extend discussion by discussing independent vs. dependent variable, slope, etc.
7. Follow steps 3-5 with situation 2 and 3.
8. Allow students to return to their seats but have them remain in groups.
9. Distribute matching cards to groups (Appendix F)
10. Instruct students to match graph cards with situation cards.
11. Monitor students' progress and lead small group discussions when appropriate.

E. Assessment/Evaluation

1. Assessment: *Assessment for Matching Graphs and Situations* (Appendix G)

Lesson Three: Technology How-To's

A. *Daily Objectives*

1. Concept Objective(s)
    a. Students will develop an understanding of how the TI-83 Plus, CBL2, and CBR work together to electronically graph
2. Lesson Content
    a. Operating CBL2
    b. Operating CBR
    c. Integrating technology and calculators
3. Skill Objective(s)
    a. Use a CBL2 in order to collect data to produce a graph
    b. Use a TI-83 Plus calculator to graph information from a CBL2

c. Use a CBR to graph motion

B. *Materials*
1. TI-83 Plus
2. CBL2
3. CBR
4. Connecting cords
5. AA batteries
6. AAA batteries
7. Beakers
8. Ice
9. Temperature probes
10. Hot plates
11. *How to Operate the CBL2 and CBR* (Appendix H)

C. *Key Vocabulary*
1. CBL2 – Calculator Based Lab
2. CBR – Calculator Based Ranger (motion detector)
3. Temperature – the average kinetic energy of the molecules in a substance
4. Kinetic Energy – the energy of an object due to its motion
5. Potential Energy – energy associated with an object due to its position

D. *Procedures/Activities*
1. Before lesson, review how to operate the CBL2 and CBR (Appendix H).
2. Teach students how to operate the technology.
3. Demonstrate the CBL2 technology by gathering data with a temperature probe. Graph ice being warmed to boiling water on a hot plate.
4. Lead class discussion about the graph.
5. Review the workings of the technology.

E. *Assessment/Evaluation*
1. Teacher's observation of students exploring the world around them

Lesson Four: Moving for Graphs

A. *Daily Objectives*
1. Concept Objective(s)
   a. Students will develop an understanding of how their kinesthetic motion relates to time on a graph
2. Lesson Content
   a. Matching graphs with human motion
   b. Summarizing graphing experience
3. Skill Objective(s)
   a. Use a TI-83 Plus, CBL2, CBR to form graphs
   b. Match overhead graphs
   c. Match calculator produced graphs
   d. Peer evaluate partners
   e. Write a summary of the day's experience

B. Materials
1. TI-83 Plus
2. CBR
3. CBL2
4. Peer Evaluation sheets (Appendix I)
5. Graph Matching Lab (Appendix J)

C. Key Vocabulary
1. All vocabulary from lessons 1, 2, and 3

D. Procedures/Activities

1. Quickly review lesson 3
2. Put students in partners.
3. Distribute evaluation sheets to pairs (Appendix I) and Graph Matching Lab (Appendix J). Students will match graphs on the TI-83 Plus using the CBR. Each attempt to match the graph will be peer evaluated by their partner
4. Quickly summarize the experiences with graph matching… how their skills changed, what they looked for, etc

E. *Assessment/Evaluation*
   1. Written summary of the day's graphing experience

Lesson Five: Speed Demons and Other Fun Experiments (2 days)

A. *Daily Objectives*
   1. Concept Objective(s)
      a. Students will develop an understanding of basic graphing concepts such as slope, x-intercept, y-intercept, t-charts, and linear equations
      b. Students will interpret graph meaning
      c. Students will develop an understanding of how the TI-83 Plus, CBL2, and CBR work together to electronically graph
      d. Students will develop an understanding of how their kinesthetic motion relates to time on a graph
   2. Lesson Content
      a. Experimentation at different lab stations using various probes
      b. Recording data
   3. Skill Objective(s)
      a. Make predictions before seeing graphs
      b. Work with a group to use TI-83 Plus, CBR, CBL2 to collect data
      c. Manually transfer graph from calculator to paper
      d. Make t-charts from graphs
      e. Compare/contrast different graphs

B. *Materials*
   1. See Appendix K for materials for each lab

C. *Key Vocabulary*
   1. T-chart- a table that is used to show the x and y coordinates of a line
   2. electricity – a form of energy that occurs in nature and is observable; a natural phenomenon that can be produced by friction
   3. Circuit – any complete path along which charge can flow
   4. Conductor – material through which electric charge can flow (usually a metal)
   5. Electron – negatively charged subatomic particle
   6. Charge – the fundamental electrical property to which the mutual attractions or repulsions between electrons or protons is attributed
   7. Volts – the SI unit of electric potential; one volt (V) is the electric potential difference across which 1 coulomb of charge gains or loses one joule of energy

D. *Procedures/Activities*
   1. Set up stations with the following: calculator, CBL2, probe, lab instructions, and additional material depending on lab. (Appendix K)
   2. Divide students into groups.
   3. Explain procedure and distribute lab sheets to each student. (Appendix K)
   4. Instruct the students to move through stations (approximately 15 min. each).

E. *Assessment/Evaluation*
   1. Lab sheets (Appendix K)

VI. CULMINATING ACTIVITY

A. Students will be divided into groups of 3 or 4. Each group will be given a graph and a box of items. The group will be expected to create a situation with the provided items that will match the given graph. Items should include: books, plywood scraps for ramps, balloons, index cards, tape, marbles, hot wheel cars, tennis ball, racquet ball, whiffle ball, rubber tubing cut length-wise, and any other items that are readily available and would produce interesting results.

VII. HANDOUTS/WORKSHEETS

Appendices A - K

VIII. BIBLIOGRAPHY

A. Voltz, Donald L. and Sapatka, Sandy, Middle School Science with Calculators Beaverton, OR: Vernier Software and Technology, 2000.ISBN # 1-929075-08-1

B. Larson, Roland E. et al, Heath Algebra 1: An Integrated Approach. Evanston, IL: McDougal Littell, 1998. ISBN # 0-669-45259-9

C. Boyd, Cindy J, Glencoe Algebra 1. New York: McGraw Hill, 1998. ISBN # 0-02-825327-2 TI-83 Plus Graphing Calculator Guide Book. Texas Instruments. (Accompanies purchase of TI-83 Plus Calculator).

D. Getting Started with CBL 2. Texas Instruments. (Accompanies purchase of calculator)

Appendix A

Suggested Points for Sticky-Dot Activity

Group 1

(-3, -12)
(-2, -8)
(0, 0)
(1, 4)
(2, 8)

Group 2

(-4, 2)
(-3, 3)
(-1, 5)
(2, 8)
(4, 10)

Group 3

(-2, 10)
(0, 6)
(1, 4)
(5, -4)
(8, -10)

Group 4

(-2, -1)
(-1, 1)
(0, 3)
(1, 5)
(2, 7)

Group 5

(1, 11)
(2, 10)
(3, 9)
(4, 8)
(5, 7)

Appendix B

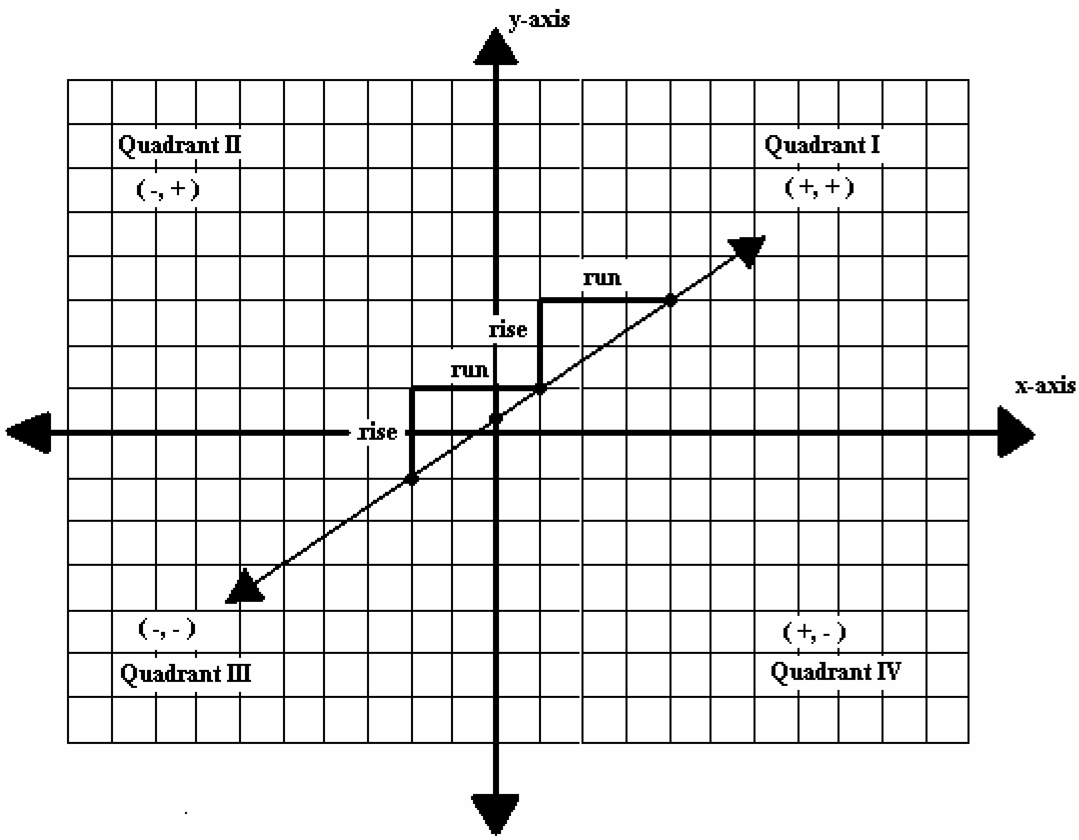
Student Directions for Sticky-Dot Activity

1. As a group, draw the x- and y-axes on your graph paper. Make sure that you divide your paper into even quadrants. Your coordinate grid should fill the size of your paper.
2. Label the axes and quadrants. Title the graph.
3. Individually locate your ordered pair from your ordered pair card. Each student should individually place a sticky-dot representing the ordered pair on the graph.
4. Label all points with the appropriate ordered pair.
5. Using the ruler, connect the points to make a straight line. If the sticky-dots do not connect to make a straight line, one or more of the ordered pairs were plotted wrong. As a group, go through the points to discover which points are incorrect. Place a new sticky-dot in the appropriate places and mark an x through the incorrect sticky-dots.
6. Display your graph.
7. Answer the following questions:

- Did your ordered pairs connect to form a line on the first try? Why or why not?
- Explain how you can tell which quadrant a point is in by just looking at the signs of its coordinates.
- Explain how an ordered pair is a set of directions when plotting a point.
- Why are the x- and y-axes not contained in any of the quadrants?
- How does the word relation apply to an ordered pair?
- What is the slope of this line?
- What is the y- intercept of this line?
- What is the equation of this line?

Appendix C

Graphing on a Coordinate Plane



→ Slope = m = $\frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1}$

→ Y- intercept: b, the point on a graph that intersects the y- axis

→ Slope-Intercept Form of a Line: $y = mx + b$

→ Independent Variable- x
Dependent Variable- y

Appendix D

Graphing Questions

Label the x- axis, y-axis and the quadrants

Graph the following equations by using a t-chart (table). Plot at least 5 points.

$y = 2x + 1$ $\qquad\qquad\qquad\qquad$ $y = \frac{1}{2} x - 2$

Graph the following equations by using the slope-intercept form of a line. Identify the slope (m) and y-intercept (b).

$y = \frac{1}{4} x + 3$ $\qquad\qquad\qquad\qquad$ $y = -2 x + 1$

Appendix E

<u>Human Graph Ordered Pairs and Questions</u>

<u>Situation 1</u>

A third-grade girl begins getting an allowance for the first time. The x- axis represents time in number of weeks, and the y- axis represents the money the girl has in dollars.

Ordered pairs

(0, 0)
(1, 2)
(2, 4)
(3, 6)
(4, 8)
(5, 10)

Discussion

Describe the graph. What do you know from the graph? What can you *not* tell from this graph?
How much money does the girl start with?
How much money does the girl have after 5 days?
How much do you predict the girl will have in 8 days?
How much does it <u>seem</u> that this girl is getting for allowance?
Could the girl be spending any of her allowance?

<u>Situation 2</u>

A bowl of water sits on the ground. The x- axis represents time in number of days. The y-axis represents the amount of water in cups.

Ordered Pairs

(0, 3)
(1, 2 ½)
(2, 2 ¼)
(3, 2)
(4, 1)
(5, ½)

Discussion

Describe what is happening in this situation.
List at least three explanations for this graph.
What do you think will happen by day 10 of this situation? Why? Could anything else happen?

Appendix E

Situation 3

A boy must walk to school. The x-axis represents time in 30-second increments. The y-axis represents the distance in yards from the boy's house.

Ordered Pairs

(0, 0)
(1, 10)
(2, 15)
(3, 15)
(4, 18)
(5, 0)

Discussion

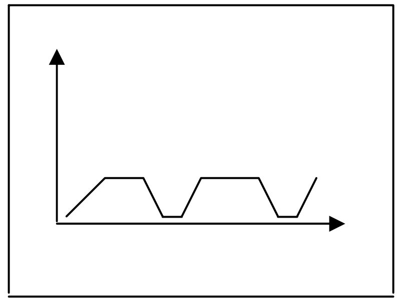
What is happening in this situation?
Give at least one explanation for what has happened.
When the x coordinate is 10, what do you think the y coordinate will be?
How predictable is this graph? Why?

Appendix F

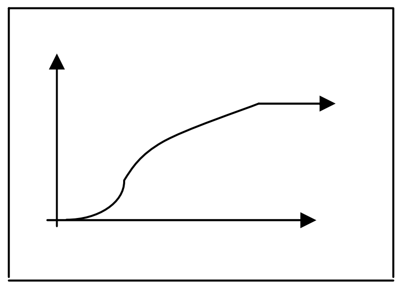
Situation/Graph Matching Activity Cards

Students will match the situation cards with the appropriate graph card. Students must decide how to label the x- axis and y- axis.

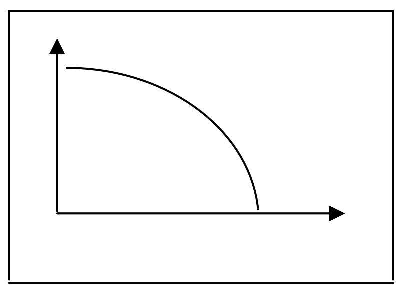
A bus frequently stops to pick up passengers



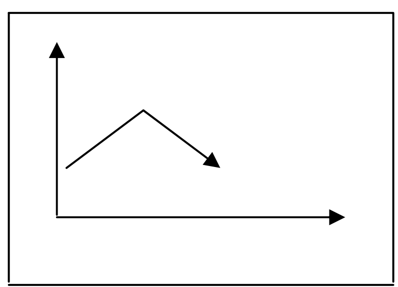
Annual income is a function of age



An object falls to the ground



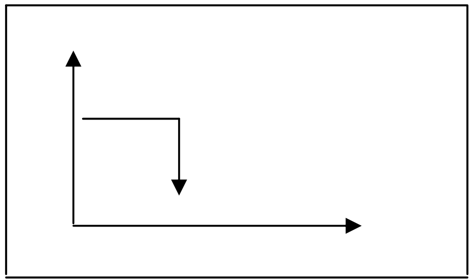
Greg adds cards to his collection at the beginning of the month, but then sells some to his next door neighbor



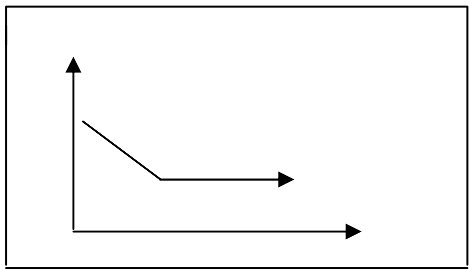
Appendix F

Situation/Graph Matching Activity Cards
Continued

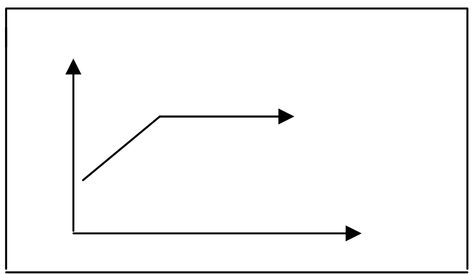
A radio controlled car crashes into a wall



Kim enters a hot house and turns on the air conditioner



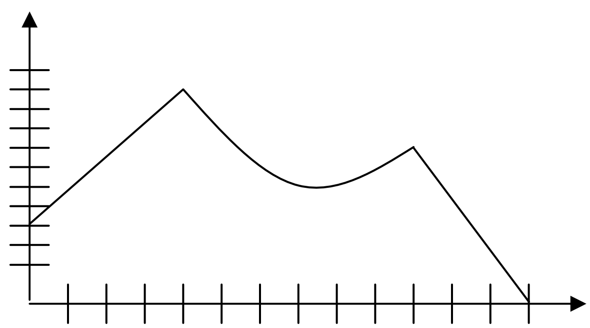
Lou enters a cold house and turns up the thermostat



Appendix G

Assessment for Matching Graphs and Situations

The following graph shows the amount of money in Stella's savings account as a function of time. The x- axis is time in months beginning with January. The y- axis is the money found in Stella's savings account in hundreds of dollars. Describe what is happening to Stella's money. Explain why the graph rises and falls at particular points.



Kelly walks up a hill at a steady pace. Then she runs down the hill. Make a sketch of the graph of the situation when the x- axis represents time and the y- axis represents speed.

Appendix H

Adapted from Getting Started with CBL 2

How to Operate the CBL 2 and CBR

Collecting Data Out of the Box Using the CBL 2™ System

1. Insert batteries into the CBL 2.

2. Connect CBL 2 to a TI graphing calculator using the unit-to-unit link cable. (Use the cradle if desired; see diagram on the cradle or the instructions on page 4.)

If you are using the TI-83 Plus or TI-83 Plus Silver Edition, proceed to step 4.

If you are using the TI-89, TI-92 Plus, or Voyage™ 200 PLT (personal learning tool) proceed to step 5.

3. Reset the memory of your calculator. Reset is necessary only for the TI-73, TI-82, and TI-83. To reset RAM, press [2nd] [MEM], choose **7:Reset**, then choose **1:All RAM**, and then choose **2:Reset**.

This is a required step due to the size of the DataMate programs that are stored in RAM.

4. Put calculator in Receive Mode (waiting to receive information):

- For TI-73, press [APPS], choose [1] LINK, press [►] to RECEIVE, and then press [ENTER].
- For the TI-82, TI-83, TI-83 Plus, and TI-83 Plus Silver Edition, press [2nd] [LINK], press [►] to RECEIVE, then press [ENTER].

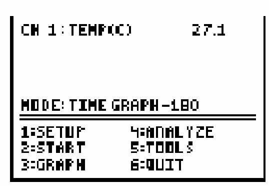
5. Press the **TRANSFER** button on the CBL 2. The CBL 2 detects the calculator to which it is connected and sends the appropriate version of the built-in DataMate software. (This software controls the CBL 2 and how it collects data.)

6. Plug your Stainless Steel Temperature sensor into Channel 1 (CH1) of the CBL 2.

7. Run DataMate:

- For TI-83 Plus and TI-83 Plus Silver Edition, press [APPS]. Press [▼] or [▲] to highlight DATAMATE and press [ENTER].
- For the TI-73, TI-82, and TI-83, press [PRGM]. Press [1] DATAMATE or press [ENTER]. DATAMATE is pasted to your home screen; press [ENTER] again to confirm your choice.
- For the TI-89, TI-92 Plus, and Voyage 200 PLT, if the Apps desktop is turned on, press [APPS], highlight DataMate, and press [ENTER].
  or
  If the Apps desktop is turned off, press [♦] [APPS], highlight DataMate, and press [ENTER].

8. DataMate automatically identifies the Stainless Steel Temperature sensor, loads its calibration factors, and displays the name of the sensor, as well as the temperature in degrees C. It also loads a default temperature experiment.



9. Start collecting data with the default experiment. Hold the temperature sensor in your hand and press [2] START to begin data collection.

Appendix H

Put the Pieces Together

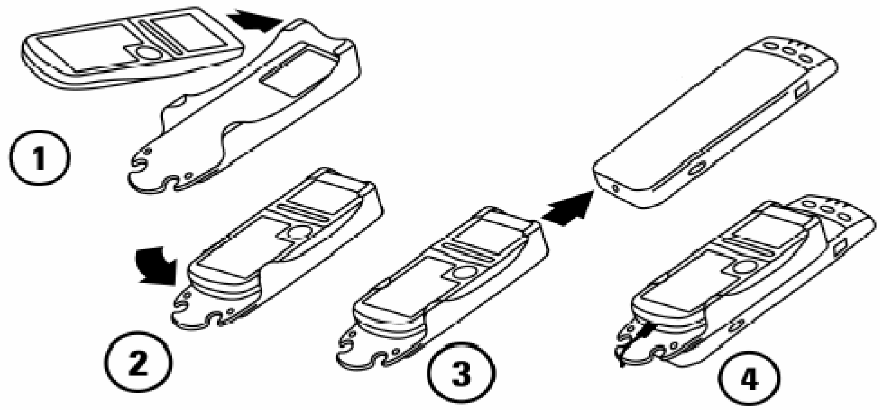


Figure 2. Connecting CBL 2 to a Calculator

1. Insert the upper end of the calculator into the cradle.
2. Press down on the lower end of the calculator until it snaps in place.
3. Slide the back of the cradle onto the front of the CBL 2 until it clicks in place.
4. Plug one end of the 6-inch unit-to-unit link cable into the I/O port in the end of the CBL 2, and plug the other end of the cable into the I/O port in the end of the calculator.

   The cradle cannot be used with the TI-92, TI-92 Plus, or Voyage™ 200 PLT. Attach these calculators using a unit-to-unit cable.

Collect the Data

To start your experiment, press [2] START on the DataMate Main Screen. The CBL 2 begins collecting data according to the data collection mode you have set.

See page 27 for a description of the data collection modes.

When you finish collecting data, the Graph Menu screen is displayed. See Graph the Data below for more information.

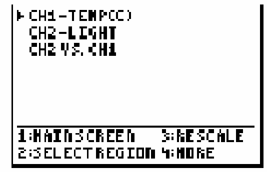
Note: In Time Graph mode, the data from CH1 is automatically graphed in REALTIME when you press [2]. Values are shown in the upper right corner of the screen as the data is plotting.

Appendix H

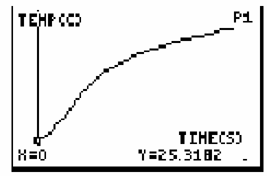
Graph the Data

1. If you have multiple sensors attached to the CBL 2™, the Graph Menu screen displays automatically when you finish collecting data.

Note: If you have only one sensor attached to the CBL 2, the graph itself displays.



2. Press [▲] or [▼] as needed to move the cursor to the channel/data you want to view as a graph and press [ENTER].

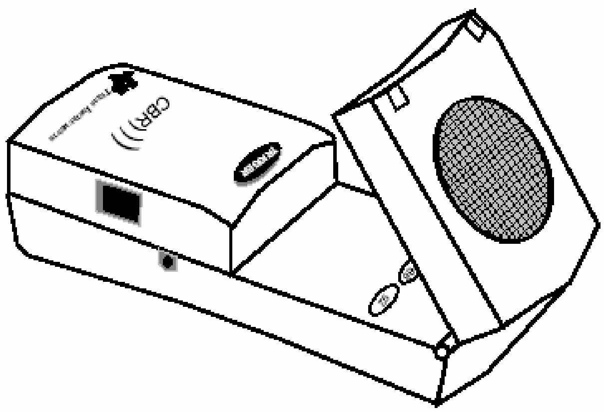


3. To view another graph, press [ENTER]. The Graph Menu screen appears again, and you can choose another channel.

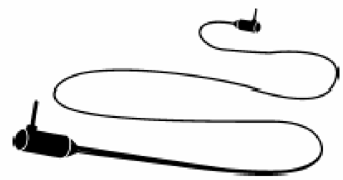
4. If you want to change the region of the graph being displayed, go back to the Graph Menu screen and press [2] SELECT REGION.
or
If you want to change the graph scale, go back to the screen in which you see your graph and press [3] RESCALE. The Rescale Graph screen appears.
or
If you are finished viewing graphs, go back to the Graph Menu screen and press [1] MAIN SCREEN.

Appendix H

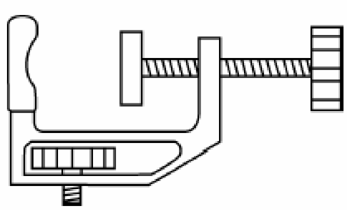
CBR Information



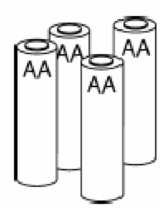
Calculator-Based Ranger™ (CBR™)



calculator-to-CBR cable

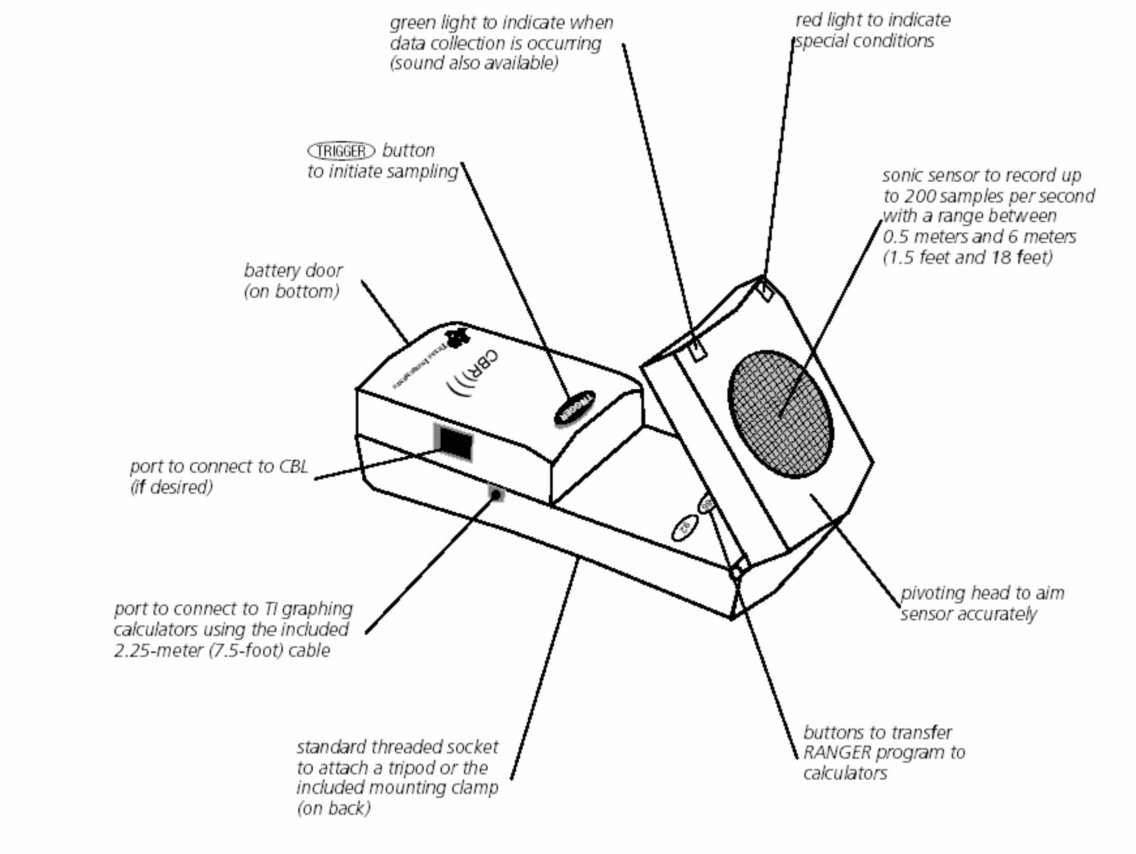


clamp



4 AA batteries

Appendix H



green light to indicate when data collection is occurring (sound also available)
red light to indicate special conditions
TRIGGER button to initiate sampling
sonic sensor to record up to 200 samples per second with a range between 0.5 meters and 6 meters (1.5 feet and 18 feet)
battery door (on bottom)
CBR
port to connect to CBL (if desired)
port to connect to TI graphing calculators using the included 2.25-meter (7.5-foot) cable
pivoting head to aim sensor accurately
standard threaded socket to attach a tripod or the included mounting clamp (on back)
buttons to transfer RANGER program to calculators

Getting started with CBR—It's as easy as 1, 2, 3

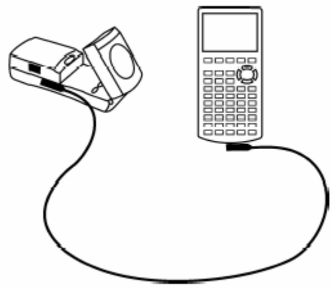
With CBR, you're just three simple steps from the first data sample!

1 Connect

Connect CBR to a TI graphing calculator using the calculator-to-CBR cable.

Push in **firmly** at both ends to make the connection.

Note: The short calculator-to-calculator cable that comes with the calculator also works.



2 Transfer

RANGER, a customized program for each calculator, is in the CBR. It's easy to transfer the appropriate program from the CBR to a calculator.

First, prepare the calculator to receive the program (see keystrokes below).

TI-82 or TI-83	TI-85/CBL or TI-86	TI-92
[2nd] [LINK] [▸] [ENTER]	[2nd] [LINK] [F2]	Go to the Home screen.

Next, open the pivoting head on the CBR, and then press the appropriate program-transfer button on the CBR.

(82/83) (85/86) (92)

During transfer, the calculator displays RECEIVING (except TI-92). When the transfer is complete, the green light on CBR flashes once, CBR beeps once, and the calculator screen displays DONE. If there is a problem, the red light on CBR flashes twice and CBR beeps twice.

Once you've transferred the RANGER program from CBR to a calculator, you won't need to transfer it to that calculator again unless you delete it from the calculator's memory.

Note: The program and data require approximately 17,500 bytes of memory. You may need to delete programs and data from the calculator. You can save the programs and data first by transferring them to a computer using TI-Graph Link™ or to another calculator using a calculator-to-calculator cable or the calculator-to-CBR cable (see calculator guidebook).

3 Run

Run the RANGER program (see keystrokes below).

TI-82 or TI-83	TI-85/CBL or TI-86	TI-92
Press [PRGM]. Choose RANGER. Press [ENTER].	Press [PRGM] [F1]. Choose RANGER. Press [ENTER].	Press [2nd] [VAR-LINK]. Choose RANGER. Press [1] [ENTER].

The opening screen is displayed.

Press [ENTER]. The MAIN MENU is displayed.

MAIN MENU	
SETUP/SAMPLE	→ view/change the settings before sampling
SET DEFAULTS	→ change the settings to the default settings
APPLICATIONS	→ DISTANCE MATCH, VELOCITY MATCH, BALL BOUNCE
PLOT MENU	→ plot options
TOOLS	→ GET CBR DATA, GET CALC DATA, STATUS, STOP/CLEAR
QUIT	

From the MAIN MENU choose SET DEFAULTS. The SETUP screen is displayed. Press [ENTER] to choose START NOW. Set up the activity, and then press [ENTER] to begin data collection. It's that easy!

For quick results, try one of the classroom-ready activities in this guide!

Important information

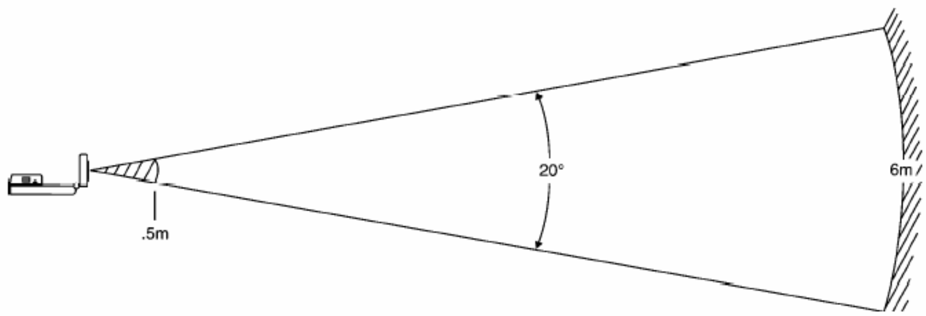
- This guide applies to all TI graphing calculators that can be used with CBR, so you may find that some of the menu names do not match exactly those on your calculator.
- When setting up activities, ensure that the CBR is securely anchored and that the cord cannot be tripped over.
- Always exit the RANGER program using the QUIT option. The RANGER program performs a proper shutdown of CBR when you choose QUIT. This ensures that CBR is properly initialized for the next time you use it.
- Always disconnect CBR from the calculator before storing it.

Appendix H

The clear zone

The path of the CBR beam is not a narrow, pencil-like beam, but fans out in all directions up to 10° in a cone-shaped beam.

To avoid interference from other objects in the vicinity, try to establish a *clear zone* in the path of the CBR beam. This helps ensure that objects other than the target do not get recorded by CBR. CBR records the closest object in the clear zone.



Reflective surfaces

Some surfaces reflect pulses better than others. For example, you might see better results with a relatively hard, smooth surfaced ball than with a tennis ball. Conversely, samples taken in a room filled with hard, reflective surfaces are more likely to show stray data points. Measurements of irregular surfaces (such as a toy car or a student holding a calculator while walking) may appear uneven.

A Distance-Time plot of a nonmoving object may have small differences in the calculated distance values. If any of these values map to a different pixel, the expected flat line may show occasional blips. The Velocity-Time plot may appear even more jagged, because the change in distance between any two points over time is, by definition, velocity. You may wish to apply an appropriate degree of smoothing to the data.

Appendix H

RANGER settings

Sample times

TIME is the total time in seconds to complete all sampling. Enter an integer between 1 second (for fast moving objects) and 99 seconds (for slow moving objects). For REALTIME=YES, TIME is always 15 seconds.

When TIME is a lower number, the object must be closer to the CBR. For example, when TIME=1 SECOND, the object can be no more than 1.75 meters (5.5 feet) from the CBR.

Starting and stopping

The SETUP screen in the RANGER program provides several options for starting and stopping sampling.

- BEGIN ON: [ENTER]. Starts sampling with the calculator's [ENTER] key when the person initiating the sampling is closest to the calculator.
- BEGIN ON: [TRIGGER]. Starts and stops sampling with the CBR (TRIGGER) button when the person initiating the sampling is closest to the CBR.

  In this option, you also can choose to detach the CBR. This lets you set up the sample, disconnect the cord from the CBR, take the CBR where the action is, press (TRIGGER), sample, reattach the CBR, and press [ENTER] to transfer the data. Use BEGIN ON: [TRIGGER] when the cord is not long enough or would interfere with data collection. This is not available in REALTIME=YES mode (such as the MATCH application).
- BEGIN ON: DELAY. Starts sampling after a 10-second delay from the time you press [ENTER]. It is especially useful when only one person is doing an activity.

Trigger button

The effect of (TRIGGER) varies depending on the settings.

- (TRIGGER) starts sampling, even if BEGIN ON: [ENTER] or BEGIN ON: DELAY is selected. It also stops sampling, but usually you will want to let a sample complete.
- In REALTIME=NO, after sampling has stopped, (TRIGGER) automatically repeats the most recent sample, but does not transfer the data to the calculator. To transfer this data, from the MAIN MENU choose TOOLS, and then choose GET CBR DATA. (You also can repeat a sample by choosing REPEAT SAMPLE from the PLOT MENU or START NOW from the SETUP screen.)

Appendix I

Peer Evaluation Sheet for Graph Matching Activities

Name:
Name of Partner:

Draw the graph that is
to be matched
by your partner

Draw the graph that your partner
made with his/her
movement.

1. Explain the problems that your partner had in respect to matching the x- coordinate or independent variable (time) with the y- coordinate or dependent variable (distance from CBR).

2. What should your partner have done to more successfully match the graph?

3. Evaluate your partner. Was he/she successful?

Draw the graph that is
to be matched
by your partner

Draw the graph that your partner
made with his/her
movement.

1. Explain the problems that your partner had in respect to matching the x- coordinate or independent variable (time) with the y- coordinate or dependent variable (distance from CBR).

2. What should your partner have done to more successfully match the graph?

3. Evaluate your partner. Was he/she successful?

Appendix J
Adapted from Getting Started with CBL 2

Graph Matching Lab

Activity 1—Match the graph — notes for teachers

Concepts

Function explored: linear.

MATCH introduces the real-world concepts of distance and time—or more precisely, the concept of distance *versus* time. As students attempt to duplicate graphs by walking while seeing their motion plotted, the concept of position can be explored.

In Explorations, students are asked to convert their rate of walking in meters per second to kilometers per hours.

Once they have mastered the Distance-Time match, challenge your students to a Velocity-Time match.

Materials

- ✓ calculator
- ✓ CBR
- ✓ calculator-to-calculator cable

A TI ViewScreen™ allows other students to watch—and provides much of the fun of this activity.

Hints

Students really enjoy this activity. Plan adequate time because everybody will want to try it!

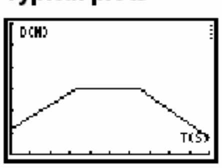
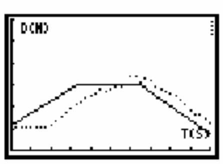
This activity works best when the student who is walking (and the entire class) can view his or her motion projected on a wall or screen using the TI ViewScreen.

Guide the students to walk in-line with the CBR; they sometimes try to walk sideways (perpendicular to the line to the CBR) or even to jump up!

Instructions suggest that the activity be done in meters, which matches the questions on the student activity sheet.

See pages 6–12 for hints on effective data collection.

Typical plots

Typical answers

1. time (from start of sample); seconds; 1 second; distance (from the CBR to the object); meters; 1 meter
2. the y-intercept represents the starting distance
3. varies by student
4. backward (increase the distance between the CBR and the object)
5. forward (decrease the distance between the CBR and the object)
6. stand still; zero slope requires no change in y (distance)
7. varies by graph; $\Delta y / 3.3$
8. varies by graph; $\Delta y / 1$
9. the segment with the greatest slope (positive or negative)
10. this is a trick question—the flat segment, because you don't move at all!
11. walking speed; when to change direction and/or speed
12. speed (or velocity)
13. varies by graph (example: 1.5 meters in 3 seconds)
14. varies by graph; example: 0.5 meters/1 second

    example: (0.5 meters / 1 second) × (60 seconds / 1 minute) = 30 meters / minute

    example: (30 meters / 1 minute) × (60 minutes / 1 hour) = 1800 meters / hour

    example: (1800 meters / 1 hour) × (1 kilometer / 1000 meter) = .18 kilometers / hour.

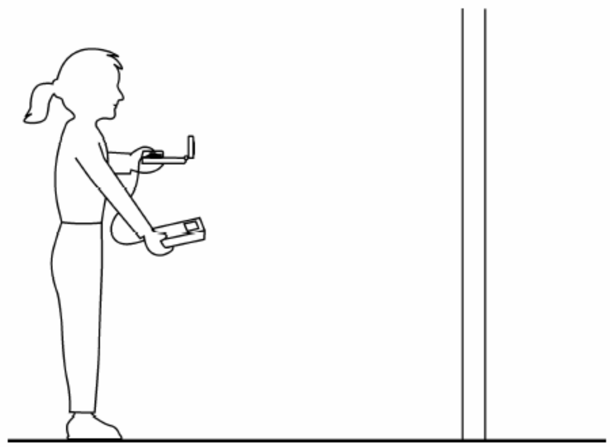
    Have students compare this last number to the velocity of a vehicle, say 96 kilometers / hour (60 miles per hour).
15. varies by graph; sum of the Δy for each line segment.

Activity 1—Match the graph *linear*

Data collection

❶ Hold the CBR in one hand, and the calculator in the other. Aim the sensor directly at a wall.

Hints: The maximum distance of any graph is 4 meters (12 feet) from the CBR. The minimum range is 0.5 meters (1.5 feet). Make sure that there is nothing in the *clear zone* (see page 7).



❷ Run the RANGER program (see page 5 for keystrokes for each calculator).

❸ From the MAIN MENU choose APPLICATIONS. Choose METERS.

❹ From the APPLICATIONS menu choose DISTANCE MATCH. General instructions are displayed. DISTANCE MATCH automatically takes care of the settings.

❺ Press [ENTER] to display the graph to match. Take a moment to study the graph. ***Answer questions 1 and 2 on the activity sheet.***

❻ Position yourself where you think the graph begins. Press [ENTER] to begin data collection. You can hear a clicking sound and see the green light as the data is collected.

❼ Walk backward and forward, and try to match the graph. Your position is plotted on the screen.

❽ When the sample is finished, examine how well your "walk" matched the graph, and then *answer question 3*.

❾ Press [ENTER] to display the OPTIONS menu and choose SAME MATCH. Try to improve your walking technique, and then ***answer questions 4, 5, and 6.***

Appendix J

Activity 1—Match the graph (cont.) linear

Explorations

In DISTANCE MATCH, all graphs are comprised of three straight-line segments.

❶ Press [ENTER] to display the OPTIONS menu and choose NEW MATCH. Study the first segment and ***answer questions 7 and 8***.

❷ Study the entire graph and ***answer questions 9 and 10***.

❸ Position yourself where you think the graph begins, press [ENTER] to begin data collection, and try to match the graph.

❹ When the sampling stops, ***answer questions 11 and 12***.

❺ Press [ENTER] to display the OPTIONS menu and choose NEW MATCH.

❻ Study the graph and ***answer questions 13, 14, and 15***.

❼ Press [ENTER] to display the OPTIONS menu. Repeat the activity if desired, or return to the MAIN MENU, and then choose QUIT to exit the RANGER program.

Appendix J

Activity 1—Match the graph

Name ______________________________

Data collection

1. What physical property is represented along the x-axis? ______________________________

What are the units? ____________________ How far apart are the tick marks? ______________

What physical property is represented along the y-axis? ______________________________

What are the units? ____________________ How far apart are the tick marks? ______________

2. How far from the CBR do you think you should stand to begin? ______________________________

3. Did you begin too close, too far, or just right? ______________________________

4. Should you walk forward or backward for a segment that slopes up? ______________________

Why? ____

5. Should you walk forward or backward for a segment that slopes down? ____________________

Why? ____

6. What should you do for a segment that is flat? ______________________________

Why? ____

Explorations

7. If you take one step every second, how long should that step be? ______________________

8. If, instead, you take steps of 1 meter (or 1 foot) in length, how many steps must you take? ______

9. For which segment will you have to move the fastest? ______________________________

Why? ____

10. For which segment will you have to move the slowest? ______________________________

Why? ____

11. In addition to choosing whether to move forward or backward, what other factors entered into matching the graph exactly? ____

____

12. What physical property does the slope, or steepness of the line segment, represent? __________

13. For the first line segment, how many meters must you walk in how many seconds? __________

14. Convert the value in question 13 (the velocity) to meters/1 second: ______________________

Convert to meters/minute: ____

Convert to meters/hour: ____

Convert to kilometers/hour: ____

15. How far did you actually walk? ____

Appendix K

Adapted from Middle School Science with Calculators

A Hot Hand

In this class, you will often work in a team using a calculator to do science. You will measure the temperature of the palm of your hand and the palm temperatures of your teammates in this experiment. In the process, you will learn how to use DataMate, a calculator program you will be using throughout the school year, and how to use Temperature Probes. You will also get to know your teammates better.

OBJECTIVES

In this experiment, you will

- use a Temperature Probe to measure temperature
- calculate temperature averages
- compare results

MATERIALS

CBL 2	beaker
TI 83+ Graphing Calculator	water
DataMate program *(on your calculator)*	paper towel
Temperature Probe	

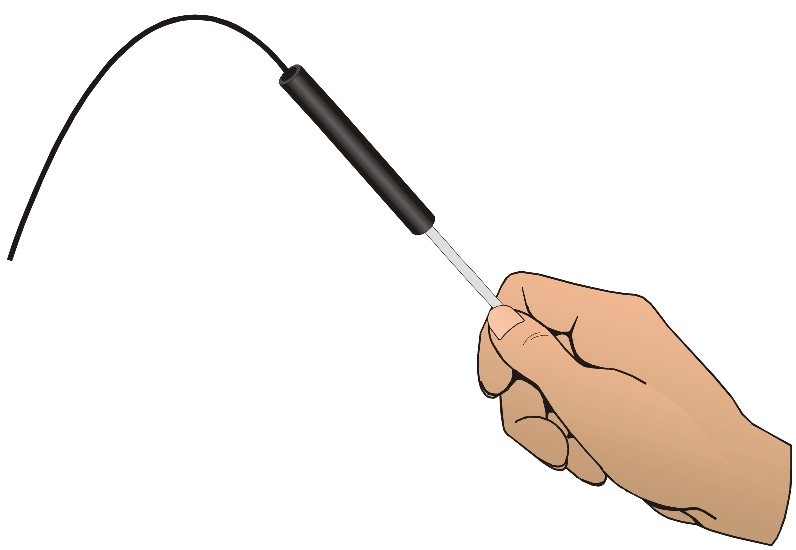


Figure 1

Appendix K

PROCEDURE

1. Plug the Temperature Probe into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

2. Turn on the calculator and follow these steps to start the DATAMATE program.

   TI-83 Plus Calculators:

   Press APPS, then press the calculator key for the *number* that precedes the DATAMATE program. You are now at the main screen of the program. Press CLEAR to reset the program.

3. Set up the calculator and interface for the correct Temperature Probe.
   a. Select SETUP from the main screen.
   b. If the calculator displays a Temperature Probe in CH 1, proceed directly to Step 4. If it does not, continue with this step to set up your sensor manually.
   c. Press ENTER to select CH 1.
   d. Select TEMPERATURE from the SELECT SENSOR menu.
   e. Select the correct Temperature Probe (in °C) from the TEMPERATURE menu.

4. Set up the calculator and interface for data collection.
   a. Use ▲ and ▼ to select MODE and press ENTER.
   b. Select TIME GRAPH from the SELECT MODE menu.
   c. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
   d. Enter “1” as the time between samples in seconds.
   e. Enter “60” as the number of samples. Data collection will last 60 seconds.
   f. Select OK to return to the setup screen.
   g. Select OK again to return to the main screen.

5. Measure the temperature of the palm of your hand.
   a. Select START to begin data collection.
   b. Pick up the Temperature Probe and hold its tip in the palm of your hand as shown in Figure 1. Data collection will end when 60 seconds have gone by.

6. Record your highest temperature.
   a. When data collection is complete after 60 seconds, a graph of temperature *vs*. time will be displayed. Use ► to examine data points along the curve. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed below the graph.
   b. Record your highest temperature (to the nearest 0.1°C).
   c. Press ENTER to return to the main screen.

8. Prepare the Temperature Probe for the next run.

a. Cool the Temperature Probe by placing it into a beaker of room-temperature water until its temperature reaches the temperature of the water. The temperature of the probe is displayed at the top of the main screen.
b. Use a paper towel to dry the probe. Be careful not to warm the probe as you dry it.

8. Repeat Steps 5-7 for each person in your team.

DATA

Student name	Highest temperature
	°C
	°C
	°C
	°C
Team average	°C

PROCESSING THE DATA

1. Calculate your team average for the highest temperatures. Record the result in the Data table above.

2. How did the highest temperatures of your teammates compare?

3. Who had the “hottest hand”?

EXTENSION

1. Determine the class average for highest temperature.

Appendix K

Lemon "Juice"

"Juice" is a slang term sometimes used for electricity. Batteries are made up of one or more cells. Cells often consist of two different materials in a solution and are connected to each other by a wire. In this experiment, you will study some basic principles of cells using the juice of a lemon as the cell solution. You will place small pieces of two different materials into the lemon, and a calculator will be used to measure and display the voltages produced.

OBJECTIVES

In this experiment, you will

- build several cells
- measure and display cell voltages
- discover which combinations produce a voltage
- decide which combination makes the "best" battery

MATERIALS

CBL 2
TI 83+ Graphing Calculator
DataMate program (on your calculator)
Voltage Probe
2 alligator clips
a lemon
graphite pencil (C)
iron nail (Fe)
magnesium strip (Mg)
zinc strip (Zn)
paper towel

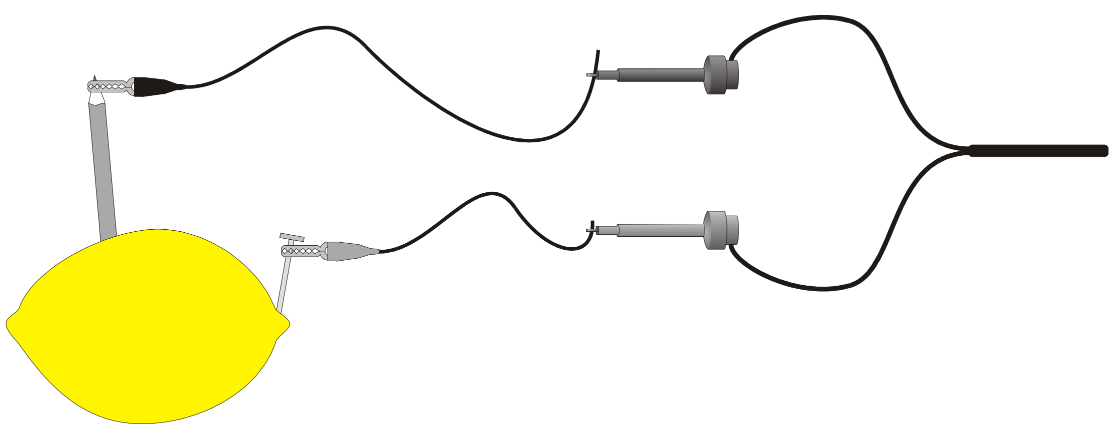


Figure 1

Appendix K

PROCEDURE

1. There are two slits cut in your lemon peel… this is where your conductors will go.

2. Attach the red Voltage Probe lead to one alligator clip and the black lead to a second alligator clip as shown in Figure 1. You will be attaching the alligator clips to the test materials during this experiment in order to prevent corrosion of the probe leads.

3. Plug the Voltage Probe into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

4. Turn on the calculator and start the DATAMATE program. Press CLEAR to reset the program.

5. Insert a short graphite pencil, sharpened at both ends, into one of the slits and an iron nail into the other. Hook the alligator clip attached to the red probe lead to the pencil. Hook the alligator clip attached to the black probe lead to the iron nail.

6. Record the voltage reading. Observe whether the voltage reading stays constant, rises, or drops. Record your observations. Note: If the two leads of the voltage probe are not connected to a cell, a meaningless reading of about 2 volts is displayed.

7. Switch the positions of the alligator clips. Record the voltage reading and your observations.

8. Repeat Steps 5-7 for the other combinations listed in the Data table. ***Dry the materials after each use.***

DATA

Probe lead		Voltage (V)	Observations	Probe lead		Voltage (V)	Observations
Red	Black			Red	Black		
C	Fe			Fe	C		
C	Mg			Mg	C		
C	Zn			Zn	C		
Fe	Mg			Mg	Fe		
Fe	Zn			Zn	Fe		
Mg	Zn			Zn	Mg		

PROCESSING THE DATA

1. What happens to the voltage reading if a cell is hooked up backwards?

2. Which combination gives the highest voltage?

3. Which combination(s) gives the steadiest voltage?

4. Which combination would make the best battery? Explain.

5. The chemical activity of metal is shown by the size of the voltage reading when the metal is paired with carbon in a cell. A high voltage indicates high chemical activity. Rank the three metals (Fe, Mg, and Zn) according to chemical activity, from highest to lowest.

EXTENSIONS

1. Measure the voltage of “lemon cells” connected in series and in parallel.
2. Try the experiment using other fruits and vegetables.
3. Do the experiment using other metals, such as aluminum, copper, and lead.

Appendix K

Cooling Rates: Shaq *vs*. Susie

Animals have different ways to keep cool in hot weather. Jackrabbits lose heat through their big ears, dogs pant, and you sweat. Body size affects cooling rate. Shaquille “Shaq” O’Neal is the 315-pound, seven-foot, one-inch center for the Los Angeles Lakers basketball team. Susie Chang is the 78-pound, four-foot, eight-inch point guard for the Milan (Indiana) Middle School Indians. Who do you think cools faster—Shaq or Susie? In this experiment, you will first predict who cools faster. Then you will do an experiment to test your prediction.

OBJECTIVES

In this experiment, you will

- predict which cools faster, a large body or a small one
- test your prediction

MATERIALS

CBL 2
TI 83 + Graphing Calculator
DataMate program (on your calculator)
2 Temperature Probes
large plastic bottle (2 or 3 liter)
small plastic bottle
2 one-hole stoppers
hot tap water

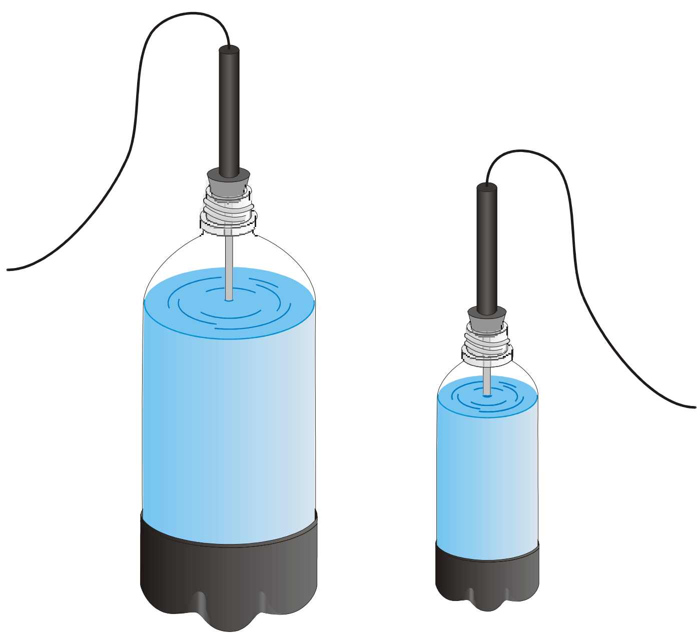


Figure 1

PRE-LAB PREDICTION

Which do you think cools faster—a large body (Shaq) or a small body (Susie)? Discuss this question with your group, then record your prediction in the space provided on your data page.

PROCEDURE

1. Plug Temperature Probe 1 into Channel 1 of the LabPro or CBL 2 interface. Plug Temperature Probe 2 into Channel 2. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.

2. Turn on the calculator and start the DATAMATE program. Press CLEAR to reset the program.

3. Set up the calculator and interface for the two Temperature Probes.
   a. Select SETUP from the main screen.
   b. If the calculator displays the correct Temperature Probes in CH 1 and CH 2, proceed directly to Step 4. If it does not, continue with this step to set up your sensors manually.
   c. Press ENTER to select CH 1.
   d. Select TEMPERATURE from the SELECT SENSOR menu.
   e. Select the correct Temperature Probe (in °C) from the TEMPERATURE menu.
   f. Use ▼ to select CH 2, then press ENTER.
   g. Select TEMPERATURE from the SELECT SENSOR menu.
   h. Select the correct Temperature Probe (in °C) from the TEMPERATURE menu.

4. Set up the calculator and interface for data collection.
   a. Use ▲ and ▼ to select MODE and press ENTER.
   b. Select TIME GRAPH from the SELECT MODE menu.
   c. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
   d. Enter "60" as the time between samples in seconds.
   e. Enter "20" as the number of samples. Data collection will last 1200 seconds (20 minutes).
   f. Select OK to return to the setup screen.
   g. Select OK again to return to the main screen.

5. Slip a one-hole stopper that fits the large bottle onto Probe 1. Slip a one-hole stopper that fits the small bottle onto Probe 2.

6. Fill the large plastic bottle and the small plastic bottle with hot tap water. **CAUTION: Be careful not to burn yourself!**

7. Place Probe 1 into the large bottle and Probe 2 into the small bottle.

Appendix K

8. Watch the temperature readings displayed at the top of the screen. When they both stop rising, select START to begin data collection. Data collection will end automatically after 1200 seconds (20 minutes).

9. Record your beginning and final temperatures.
   a. When data collection is complete after 1200 seconds, a graph of temperature *vs*. time will be displayed. Use ▶ to examine data points along the curve for Probe 1. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed below the graph. Note: P1 appears in the upper right corner of the screen.
   b. Record the beginning and final temperatures for Probe 1 (to the nearest 0.1°C).
   c. Use ▲ to move the cursor to the curve for Probe 2. Note: P2 now appears in the upper right corner of the screen. Use ▶ to examine data points along the curve for Probe 2.
   d. Record the beginning and final temperatures for Probe 2 (to the nearest 0.1°C).

10. Sketch or print the graph as directed by your teacher.

Appendix K

PRE-LAB PREDICTION

Which will cool faster— a large body (Shaq) or a small body (Susie)?

DATA

	Large bottle (Probe 1)	Small bottle (Probe 2)
Beginning temperature	°C	°C
Final temperature	°C	°C
Temperature change	°C	°C

PROCESSING THE DATA

1. In the space provided in the Data table, subtract to find the temperature change for each bottle.

2. Was there any difference in the cooling rates of the bottles? Try to explain the difference.

3. Do the results support your prediction about Shaq and Susie?

4. Who, Shaq or Susie, sweats more during a game? Why?

Appendix K

The Indy 100

In this activity, you will race a car down a ramp. The fastest car will be the one that reaches the highest velocity going down the ramp. Velocity will be measured with a Motion Detector.

OBJECTIVES

In this experiment, you will

- prepare a car for a race
- measure velocity using a Motion Detector
- determine the fastest car in your class

MATERIALS

LabPro or CBL 2 interface	several books
TI Graphing Calculator	meter stick
DataMate program	masking tape
Vernier Motion Detector	car with a card attached
1.8-m board	

GUIDELINES

1. You may build a car, use your own car, or temporarily modify a laboratory car supplied by your teacher. You are encouraged to make changes that will increase the speed of the car.

2. You will use the same setup as in Experiment 34, “Velocity.” A Motion Detector will be used to measure the maximum velocity of your car.

3. All cars should start with their front wheels at the 100-cm mark on the same ramp.

4. The car must be released without being pushed or pulled.

5. You will be allowed two runs. The greatest velocity measured during your two runs will be the one counted. The winning car will the one with the greatest velocity.

6. Experiment and practice with your car before the actual race.

Appendix K

Falling Objects

Galileo tried to prove that all falling objects accelerate downward at the same rate. Falling objects do accelerate downward at the same rate in a vacuum. Air resistance, however, can cause objects to fall at different rates in air. Air resistance enables a skydiver's parachute to slow his or her fall. Because of air resistance, falling objects can reach a maximum velocity or *terminal velocity*. In this experiment, you will study the velocities of two different falling objects.

OBJECTIVES

In this experiment, you will

- use a Motion Detector to measure distance and velocity
- produce distance *vs*. time and velocity *vs*. time graphs
- analyze and explain the results

MATERIALS

LabPro or CBL 2 interface
TI Graphing Calculator
DataMate program
Vernier Motion Detector
ring stand
metal rod
right-angle clamp
basket coffee filter
3 books
meter stick

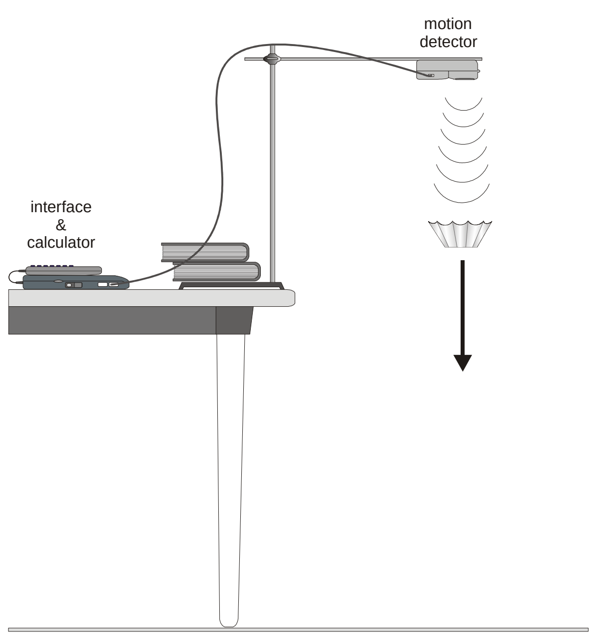


Figure 1

PROCEDURE

Part A Falling Coffee Filter

1. Set up the apparatus as shown in Figure 1.
   a. Place two books on the base of a ring stand to keep it from falling.
   b. Use a right-angle clamp to fasten a metal rod to the ring stand. If you do not have a right angle clamp, hold the Motion Detector at a steady spot parallel to the floor.
   c. Fasten a Motion Detector under one end of the rod. The Motion Detector should face down and be parallel to the floor.
   d. Move the right-angle clamp, rod, and Motion Detector to the top of the ring stand.
   e. Use a piece of tape to mark a spot on the ring stand that is 50 cm from the right-angle clamp.
   f. Place the ring stand, with the Motion Detector attached, at the edge of your lab table. The Motion Detector must extend 50 cm beyond the table edge.

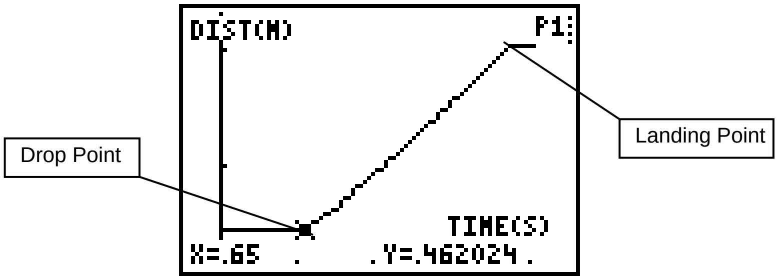
2. Plug the Motion Detector into the DIG/SONIC 1 port of the CBL 2 interface. Use the link cable to connect the TI 83 + Graphing Calculator to the CBL 2. Firmly press in the cable ends.

3. Turn on the calculator and start the DATAMATE program. Press CLEAR to reset the program.

4. Set up the calculator and interface for data collection.
   a. Select SETUP from the main screen.
   b. Use ▲ and ▼ to select MODE and press ENTER.
   c. Select TIME GRAPH from the SELECT MODE menu.
   d. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
   e. Enter "0.2" as the time between samples in seconds.
   f. Enter "15" as the number of samples. Data collection will last 3 seconds.
   g. Select OK to return to the setup screen.
   h. Select OK again to return to the main screen.

5. Collect data for a falling coffee filter.
   a. Hold a basket coffee filter with the open side facing up at a position 0.5 m from (at the 0.5-m mark on the ring stand) and directly below the Motion Detector.
   b. Select START to begin data collection.
   c. When you hear sound coming from the Motion Detector, allow the coffee filter to drop straight down.

6. Examine the distance *vs.* time graph for the falling coffee filter.
   a. After data collection stops, Use ▼ to select DIG-DISTANCE and press ENTER.
   b. Examine the graph and discuss it with your lab partners. If it is satisfactory, sketch the graph in the space provided in the Data section. Label the important features of your graph. If necessary, repeat the drop.



c. Position the cursor at the filter's drop point. See the example above. Record the time (X) and distance (Y) in the Data table (round to the nearest 0.01). In the example above, the time is 0.65 s and distance is 0.46 m.

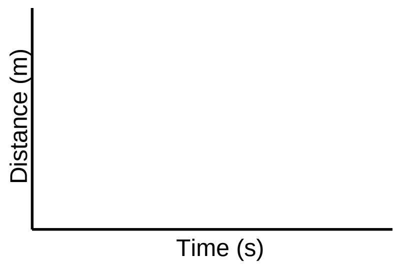
d. Position the cursor at the filter's landing point. See the example above for the location of the landing point. Record the time (X) and distance (Y) when the filter landed in the Data table (to the nearest 0.01).

Part B Falling Book

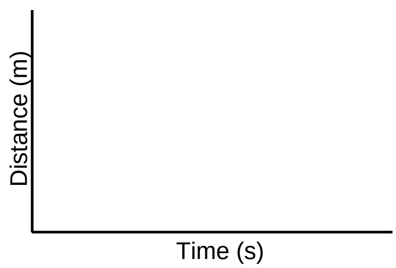
8. Collect data for a falling book.
   a. Press ENTER.
   b. Select MAIN SCREEN to return to the main screen.
   c. Repeat Steps 5-7 using a book.

DATA

Falling Coffee Filter



Falling Book



Appendix K

	Falling coffee filter		Falling book	
	Distance (Y)	Time (X)	Distance (Y)	Time (X)
Drop point	m	s	m	s
Landing point	m	s	m	s

PROCESSING THE DATA

1. Calculate the distance fallen (in m) for each object. (Subtract the drop-point distance from the landing-point distance.)

   Falling Coffee Filter   Falling Book

2. How do the distances compare? Why do the distances compare this way?

3. Calculate the falling time (in s) for each object. (Subtract the drop-point time from the landing-point time.)

   Falling Coffee Filter   Falling Book

4. How do the falling times compare?

5. Which object fell faster? Why?

6. How are the two distance *vs*. time graphs different? Explain the differences.

7. For which object is air resistance more important? Why does air resistance affect this object more than the other object?

EXTENSIONS

Study the falling behavior of stacks of 1, 2, 3, 4, and 5 coffee filters.

Appendix K

Falling Objects 2

Galileo tried to prove that all falling objects accelerate downward at the same rate. Falling objects do accelerate downward at the same rate in a vacuum. Air resistance, however, can cause objects to fall at different rates in air. Air resistance enables a skydiver's parachute to slow his or her fall. Because of air resistance, falling objects can reach a maximum velocity or *terminal velocity*. In this experiment, you will study the velocities of two different falling objects.

OBJECTIVES

In this experiment, you will

- use a Motion Detector to measure distance and velocity
- produce distance *vs*. time
- analyze and explain the results

MATERIALS

CBL 2 interface
TI 83 + Graphing Calculator
DataMate program (on your calculator)
Vernier Motion Detector (CBR)
ring stand
metal rod
right-angle clamp
basket coffee filters
Tennis ball
meter stick

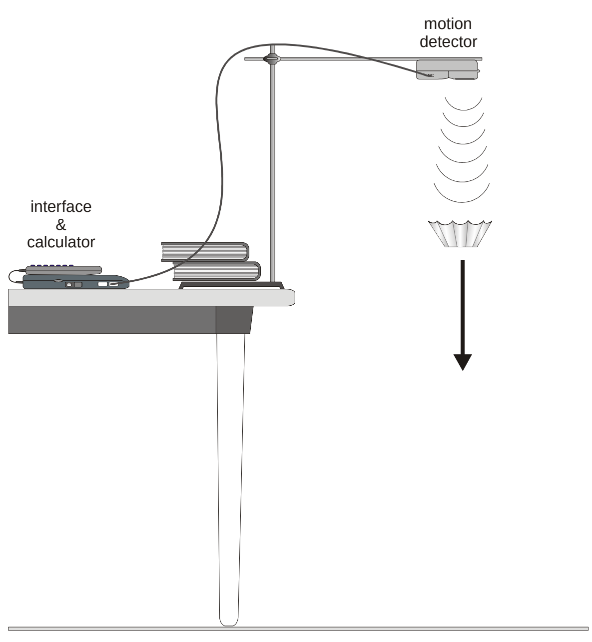


Figure 1

PROCEDURE

Part A Falling Coffee Filter

1. Set up the apparatus as shown in Figure 1.
   g. Place two books on the base of a ring stand to keep it from falling.
   h. Use a right-angle clamp to fasten a metal rod to the ring stand. If you do not have a right angle clamp, hold the Motion Detector at a steady spot parallel to the floor.
   i. Fasten a Motion Detector under one end of the rod. The Motion Detector should face down and be parallel to the floor.
   j. Move the right-angle clamp, rod, and Motion Detector to the top of the ring stand.
   k. Use a piece of tape to mark a spot on the ring stand that is 50 cm from the right-angle clamp.
   l. Place the ring stand, with the Motion Detector attached, at the edge of your lab table. The Motion Detector must extend 50 cm beyond the table edge.

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   i. Select SETUP from the main screen.
   j. Use ▲ and ▼ to select MODE and press ENTER.
   k. Select TIME GRAPH from the SELECT MODE menu.
   l. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
   m. Enter “0.2” as the time between samples in seconds.
   n. Enter “15” as the number of samples. Data collection will last 3 seconds.
   o. Select OK to return to the setup screen.
   p. Select OK again to return to the main screen.

5. Collect data for a falling coffee filter.
   d. Hold a basket coffee filter with the open side facing up at a position 0.5 m from (at the 0.5-m mark on the ring stand) and directly below the Motion Detector.
   e. Select START to begin data collection.
   f. When you hear sound coming from the Motion Detector, allow the coffee filter to drop straight down.

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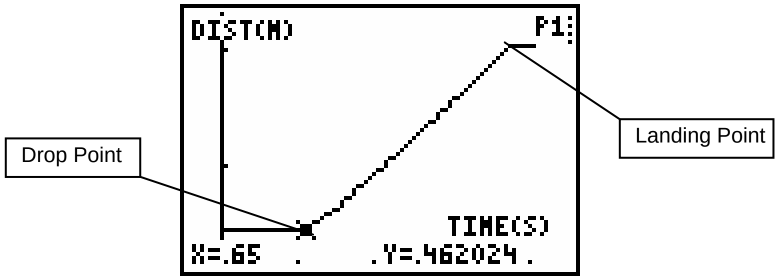
Appendix K



e. Position the cursor at the filter's drop point. See the example above. Record the time (X) and distance (Y) in the Data table (round to the nearest 0.01). In the example above, the time is 0.65 s and distance is 0.46 m.

f. Position the cursor at the filter's landing point. See the example above for the location of the landing point. Record the time (X) and distance (Y) when the filter landed in the Data table (to the nearest 0.01).

Part B Falling Ball

8. Collect data for a falling tennis ball.

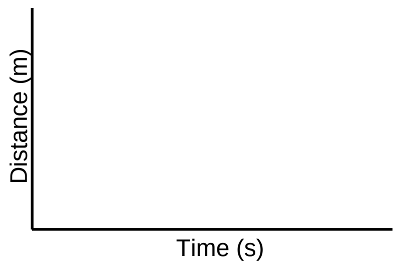
   d. Press ENTER.

   e. Select MAIN SCREEN to return to the main screen.

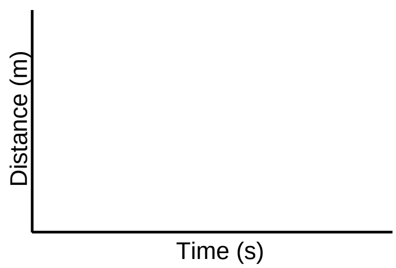
   f. Repeat Steps 5-7 using a tennis ball.

DATA

Falling Coffee Filter



Falling Ball



Appendix K

	Falling coffee filter		Falling ball	
	Distance (Y)	Time (X)	Distance (Y)	Time (X)
Drop point	m	s	m	s
Landing point	m	s	m	s

PROCESSING THE DATA

1. Calculate the distance fallen (in m) for each object. (Subtract the drop-point distance from the landing-point distance.)

   Falling Coffee Filter   Falling Ball

2. How do the distances compare? Why do the distances compare this way?

3. Calculate the falling time (in s) for each object. (Subtract the drop-point time from the landing-point time.)

   Falling Coffee Filter   Falling Book

4. How do the falling times compare?

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EXTENSIONS

Study the falling behavior of stacks of 1, 2, 3, 4, and 5 coffee filters.