Science Skill Builders: Interpreting Data, Making Data Tables, Bar and Line Graphs

The sample lessons provided here build on one another and help students build on their own skills. **Note: these lessons work best in sequential order.** These tips will help you make the most of this lesson series.

- Begin with the lesson on Interpreting Data from Bird Feeders.
- Next, complete the lesson on Learning to Make Data Tables.
- Use the data tables that students create to complete the lessons on line graphs and bar graphs.
- The lesson on Learning to Make Bar Graphs is ideal for students in the primary and upper elementary grades, but can be used for older students who struggle with this concept.
- The lesson on Learning to Make Line Graphs is ideal for students in upper elementary grades, middle school.

Here are some things to think about when helping students increase their understanding of science content and improve their skills.

- Complete each lesson on your own before working with students. Use the guidelines provided in each lesson.
- Provide encouragement. Remind students that science is fun, that it is for all students, and that everyone can succeed.
- Set the tone by asking questions that keep students thinking, learning for themselves, and assessing their progress. Remember that giving answers without asking students to reason and think for themselves inhibits learning. Give information as often as is needed to clarify or redirect thinking.
- Provide positive feedback and be generous with praise.
- As students' confidence increases, challenge students to use what they know to solve a problem.

Use the materials in these lessons to help students with a common problem—recording, displaying, graphing, analyzing, and interpreting data.

Next, have students apply what they have learned to the Sink or Float and/or Flying Things assignments.

Interpreting Data from Birdfeeders (Grades 2-5)

Students look at data tables and bar graphs showing patterns among different birds at birdfeeders.

Interpreting Data from Birdfeeders (2-5)
Duration: One or two 45-minute sessions
Learning Goals

- Understand and interpret data from tables and bar graphs
- Identify parts of a graph and data table including title, independent variable, dependent variable, scale, and X and Y ordered pairs
- Work cooperatively

Materials Needed

- **Tutoring One: Interpreting Data from Birdfeeders** (handout)
- Pencils and paper
- Materials to build birdfeeders (if lesson is extended)

Preparation

- Collect informational books on birds.
- Review the lesson, printouts.
- Precautions should be taken with tools if making birdfeeders.

What to Do

- **Engage** students in the lesson by reading a book together on birds and talking about the different kinds of birds in your area. Ask questions such as: What do birds need to survive? Do you think all birds eat the same thing? How might you find out what different birds eat?
- **Explore** the data about birdfeeding habits in the data tables and the bar graph that illustrates patterns at birdfeeders. Use the guiding questions to help students make sense of the data tables and bar graph. For example, students should be able to identify what kinds of birdfeed different birds prefer, what the most/least popular kind of birdfeed is, and other patterns.
- **Explain** the data. Students should be able to interpret the data based on their answers to the questions.
    - Help students understand that an independent variable is something that the person doing the experiment can control or vary—in this case the birdfeed. Likewise, help students understand that a dependent variable is something that the experimentor doesn't control or something that depends on the way the experiment is done—in this case the number of birds that eat each kind of birdfeed.
    - Discuss the patterns that students notice, questions they can use to help them interpret data tables and bar graphs, and what they learn from this activity.

- **Extend** learning if time allows by building birdfeeders or conducting a bird field study. Design an investigation to identify and count the number of birds in your area. Then display the data in data tables and in a bar graph.

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Tutoring One: Interpreting Data from Birdfeeders

Birds Attracted to Different Types of Birdfeed

Team Name	Number of Birds					Average Number of Birds
	Day 1	Day 2	Day 3	Day 4	Day 5	
Millet	10	15	17	18	15	15
Milo	2	4	5	5	4	4
Cracked Corn	3	6	8	7	6	6
Safflower	15	10	13	11	11	12
Sunflower	26	28	26	22	28	26
Nyjer (Thistle)	4	3	5	4	4	4
Suet	17	13	15	16	14	15

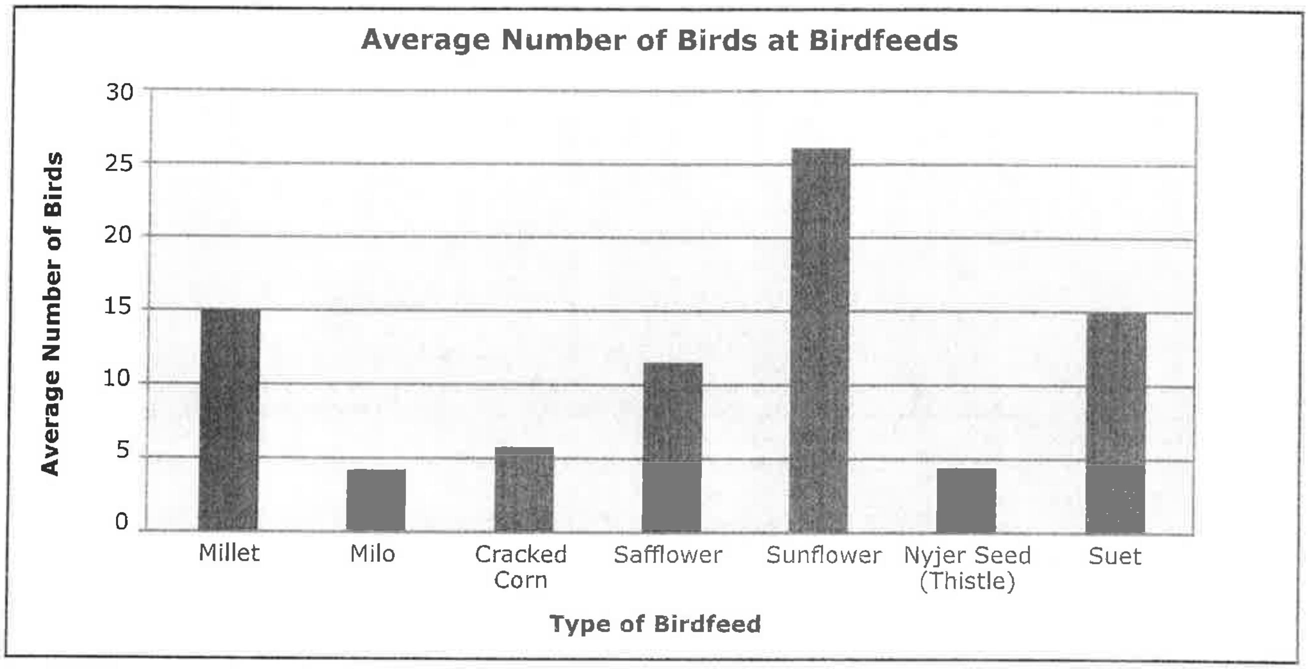
Using the data table, answer the following questions.

1. Which type of birdfeed was the favorite choice of most of the birds?
2. Which type of birdfeed was the least favorite choice?
3. Which combination of three types of feed would probably attract the most birds to the bird feeder?
4. How many days did the students collect data?
5. What were some things that should have been held constant? (For example, the weather, the time of day that the birdfeed was put out, or anything else that might have affected the outcomes.)
6. What is the independent variable in this investigation? (Hint: an independent variable is something that the investigator can control or vary.)
7. What is the dependent variable in this investigation? (Hint: a dependent variable is something that the investigator can't control or is dependent on the experiment.)

8. How many trials were there?

9. What is the title of the data table? Can you think of a better title?

The following bar graph was made using the birdfeed data.



Answer the following questions using this graph.

1. Which type of birdfeed was the favorite choice of most of the birds?
2. Which type of birdfeed was the least favorite choice?
3. Which combination of three types of feed would probably attract the most birds to the birdfeeder?
4. Which two types of birdfeed attracted the same number of birds?
5. Does the graph help you answer the questions? What could you do to the graph to make it easier to read?
6. What is the title of the graph?
7. What is value of each line on the y axis? (Hint: the y axis is verticle)
8. What is the label on the x axis? (Hint: the x axis is horizontal)
9. What is the label on the y axis?

Food Preferences of Common Feeder Birds

Kinds of Birds	Food Preferences						
	Sunflower	**Safflower**	**Corn**	**Millet**	**Milo**	**Nyjer**	**Suet**
Chickadees, Titmice, Nuthatches	X	X					X
Finches	X	X		X		X	
Cardinals, Grosbeaks	X	X					
Sparrows, Blackbirds	X		X	X			
Jays	X		X		X		X
Woodpeckers	X						X
Orioles, Tanagers							X
Pigeons, Doves			X	X	X		
Indigo Buntings	X			X		X	

Data Source: *Cornell Lab of Ornithology's Seed Preference Test*, Winter 1993-1994, sponsored by National Science Foundation.

Answer the following questions based on the information in the data table above.

1. Which birdfeed do most birds prefer?
2. What foods do finches prefer?
3. If you want to attract orioles to a birdfeeder, what food must be available?
4. Which birds like suet?
5. What foods do both chickadees and cardinals prefer?
6. If you were going to make a mix of three kinds of feed to attract the most birds, what would you choose? Explain your answer. What kinds of birds would come to the feeder?
7. What other patterns do you find in the data?

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Tutoring Two: Learning to Make Data Tables

Checklist for a Data Table

Criteria	Self		Tutor	
	Yes	No	Yes	No
Is there a title? Is the source of the data noted? Does the table have a name and a date?				
Is the title clear and does it reflect the purpose of the data table?				
Is the independent variable in the first column?				
Is the independent variable named?				
Is the independent variable unit included, if appropriate?				
Is there a column (sometimes with sub-columns) for the dependent variable?				
Is the dependent variable named?				
Is the dependent variable unit included, if appropriate?				
Are there trial sub-columns under the dependent variable (one for each trial)?				
Is there a column for a derived or calculated quantity?				
Is the derived (e.g., average) column on the far right?				
Is the derived quantity named?				
Is the derived quantity unit included, if appropriate?				
Are the derived calculations correct?				
Are data recorded correctly?				

Learning to Make Data Tables (Grades 3-8)

Students take the results, or data, from different experiments and learn to make data tables.

Note: This is the second lesson in a series. Start with Interpreting Data from Birdfeeders.
Learning to Make Data Tables
Duration: Two 45-minute sessions
Learning Goals

- Understand data as pieces of information
- Learn how data can be represented in a table
- Construct a data table from experiment results
- Interpret data from a data table

Materials Needed

- Notebook paper
- Pencils
- Clear ruler
- Graphing paper (optional)
- Large chart paper for K-2 students (optional)

Preparation

- Review the lesson, printouts.
- Make copies as needed.

What to Do

- **Engage** students by identifying what they already know about displaying data.
    - Begin by reviewing data as pieces of collected information. Typically, data represents something that can be observed and measured, from how often it rained in the last week to how much chlorine is in local pools.
    - Ask students to show you a sample of a data table or graph they have made. This may be a crumpled sheet of paper with numbers clustered randomly, representing something they have observed and measured.
    - Review the **Sample Data for Data Tables** and ask students to make a data table from one of the examples. Note what students understand and where they need to modify their thinking.
- **Explore** data tables. Review the **Guidelines for Making a Data Table** and the **Checklist for a Data Table.**
    - Ask students to select an example from the sample data and create a data table.
    - As students work, review any vocabulary associated with data representations. Watch for typical errors and help students learn to identify them, check their work, and correct errors independently.
- **Explain** the results. Ask students to explain how they organized the data in their data tables. Review students' data tables using the data table checklist. If you feel that sufficient progress has been made, ask students to continue with other sample data sets.
- **Extend** learning if you have extra time. Use school-day science lessons or the Internet to collect additional data for more data tables. If you are familiar with Microsoft Excel®, teach students to create electronic data tables.

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Tutoring Two: Learning to Make Data Tables

Sample Data for Data Tables

Use these data to create data tables following the Guidelines for Making a Data Table and Checklist for a Data Table.

Example 1: Pet Survey (GR 2–3)

Ms. Hubert's afterschool students took a survey of the 600 students at Morales Elementary School. Students were asked to select their favorite pet from a list of eight animals. Here are the results.

Lizard 25, Dog 250, Cat 115, Bird 50, Guinea pig 30, Hamster 45, Fish 75, Ferret 10

Example 2: Electromagnets—Increasing Coils (GR 3–5)

The following data were collected using an electromagnet with a 1.5 volt battery, a switch, a piece of #20 insulated wire, and a nail. Three trials were run. *Safety precautions in repeating this experiment include using safety goggles or safety spectacles and avoiding short circuits.*

Number of Coils	Number of Paperclips
5	3, 5, 4
10	7, 8, 6
15	11, 10, 12
20	15, 13, 14

Example 3: pH of Substances (GR 5–10)

The following are pH values of common household substances taken by three different teams using pH probes. *Safety precautions in repeating this experiment include hooded ventilation, chemical-splash safety goggles, gloves, and apron. Do not use bleach, ammonia, or strong acids with children.*

Lemon juice 2.4, 2.0, 2.2; Baking soda (1 Tbsp) in Water (1 cup) 8.4, 8.3, 8.7; Orange juice 3.5, 4.0, 3.4; Battery acid 1.0, 0.7, 0.5; Apples 3.0, 3.2, 3.5; Tomatoes 4.5, 4.2, 4.0; Bottled water 6.7, 7.0, 7.2; Milk of magnesia 10.5, 10.3, 10.6; Liquid hand soap 9.0, 10.0, 9.5; Vinegar 2.2, 2.9, 3.0; Household bleach 12.5, 12.5, 12.7; Milk 6.6, 6.5, 6.4; Household ammonia 11.5, 11.0, 11.5; Lye 13.0, 13.5, 13.4; and Sodium hydroxide 14.0, 14.0, 13.9; Anti-freeze 10.1, 10.9, 9.7; Windex 9.9. 10.2, 9.5; Liquid detergent 10.5, 10.0, 10.3; and Cola 3.0, 2.5, 3.2

Teaching tip: *The pH scale is from 0 to 14. Have students make two data tables, one with the data as given and one with the pH scale 0 to 14 with the substances' average pH in rank order on the scale (Battery acid at the lower end and Sodium hydroxide at the upper end) or create a pH graphic organizer.*

Example 4: Automobile Land Speed Records (GR 5-10)
In the first recorded automobile race in 1898, Count Gaston de Chasseloup-Laubat of Paris, France, drove 1 kilometer in 57 seconds for an average speed of 39.2 miles per hour (mph) or 63.1 kilometers per hour (kph). In 1904, Henry Ford drove his Ford Arrow across frozen Lake St. Clair, MI, at an average speed of 91.4 mph. Now, the North American Eagle is trying to break a land speed record of 800 mph. The Federation International de L'Automobile (FIA), the world's governing body for motor sport and land speed records, recorded the following land speed records. (Retrieved on February 5, 2006, from http://www.landspeed.com/lsrinfo.asp.)

Speed (mph)	Driver	Car	Engine	Date
407.447	Craig Breedlove	Spirit of America	GE J47	8/5/63
413.199	Tom Green	Wingfoot Express	WE J46	10/2/64
434.22	Art Arfons	Green Monster	GE J79	10/5/64
468.719	Craig Breedlove	Spirit of America	GE J79	10/13/64
526.277	Craig Breedlove	Spirit of America	GE J79	10/15/65
536.712	Art Arfons	Green Monster	GE J79	10/27/65
555.127	Craig Breedlove	Spirit of America, Sonic 1	GE J79	11/2/65
576.553	Art Arfons	Green Monster	GE J79	11/7/65
600.601	Craig Breedlove	Spirit of America, Sonic 1	GE J79	11/15/65
622.407	Gary Gabelich	Blue Flame	Rocket	10/23/70
633.468	Richard Noble	Thrust 2	RR RG 146	10/4/83
763.035	Andy Green	Thrust SSC	RR Spey	10/15/97

Example 5: Distance and Time (GR 8-10)
The following data were collected using a car with a water clock set to release a drop in a unit of time and a meter stick. The car rolled down an inclined plane. Three trials were run. Create a data table with an average distance column and an average velocity column, create an average distance-time graph, and draw the best-fit line or curve. Estimate the car's distance traveled and velocity at six drops of water. Describe the motion of the car. Is it going at a constant speed, accelerating, or decelerating? How do you know?

Time (drops of water)	Distance (cm)
1	10,11,9
2	29, 31, 30
3	59, 58, 61
4	102, 100, 98
5	122, 125, 127

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Tutoring Two: Learning to Make Data Tables

Guidelines for Making a Data Table

In most cases, the independent variable (that which you purposefully change) is in the left column, the dependent variable (that which you measure) with the different trials is in the next columns, and the derived or calculated column (often average) is on the far right. Reaffirm that rows are a series of horizontal cells and that columns are a series of vertical cells.

Title: Clearly state the purpose of the experiment (e.g., The effect of _____ (independent variable) on _______ (dependent variable).

Independent Variable (unit)	Dependent Variable (unit)			Derived Quantity (unit)
	Trial 1	Trial 2	Trial 3	

Note: This data table format is adapted from *Students and Research* (Cothron, Giese, and Rezba, 2000).

Have students practice creating data tables first with paper, pencil, and rulers, and later with Excel if computers are available. Use sample data, experimental data from investigations, or create data sets to allow for ample practice.

Example
Title: The pH of Common Household Substances

Substance	pH			Average pH
	Trial 1	Trial 2	Trial 3	
Lemon juice	2.4	2.0	2.2	2.2
Baking soda	8.4	8.3	8.7	8.5
Orange juice	3.5	4.0	3.4	3.6

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Tutoring to Enhance Science Skills

Tutoring Two: Learning to Make Data Tables

Checklist for a Data Table

Criteria	Self		Tutor	
	Yes	No	Yes	No
Is there a title? Is the source of the data noted? Does the table have a name and a date?				
Is the title clear and does it reflect the purpose of the data table?				
Is the independent variable in the first column?				
Is the independent variable named?				
Is the independent variable unit included, if appropriate?				
Is there a column (sometimes with sub-columns) for the dependent variable?				
Is the dependent variable named?				
Is the dependent variable unit included, if appropriate?				
Are there trial sub-columns under the dependent variable (one for each trial)?				
Is there a column for a derived or calculated quantity?				
Is the derived (e.g., average) column on the far right?				
Is the derived quantity named?				
Is the derived quantity unit included, if appropriate?				
Are the derived calculations correct?				
Are data recorded correctly?				

Learning to Make Bar Graphs (Grades 3-8)

Students take the results, or data, from different experiments and learn to make bar graphs.

Note: This is the third lesson in a series. Start with Interpreting Data from Bird Feeders, then complete Learning to Make Data Tables.

Duration: Two 45-minute sessions

Learning Goals

- Learn how data can be represented in a bar graph
- Construct a bar graph from experiment results
- Interpret data from a bar graph

Materials Needed

- Notebook paper
- Pencil
- Clear ruler
- Graphing paper (optional)
- Large chart paper (optional)

Preparation

- Review the lesson, printouts.
- Make copies as needed.

What to Do

- **Engage** students by asking them what they already know about bar graphs, or asking them to show you a sample of any bar graphs they have made. Or, review *the* **Sample Data for a Bar Graph** *or the data table they made in the previous lesson (Learning to Make Data Tables). Select one data set and ask students how they might represent* the results in a bar graph. Note what students understand and where they need to modify their thinking.
- **Explore** bar graphs.
    - Review the **Guidelines for Making a Bar Graph** and the **Checklist for a Bar Graph**. Ask students to select an example from the sample data and create a bar graph.
    - As students work, review any vocabulary associated with data representations. Watch for typical errors and help students learn to identify them, check their work, and correct errors independently.
- **Explain** the results. Ask students to explain how they organized the data in their bar graphs. Review students' bar graphs using the bar graph checklist. If you feel that sufficient progress has been made, ask students to continue using other sample data sets to create additional bar graphs.

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Tutoring Three: Learning to Make Bar Graphs

Guidelines for Making a Bar Graph

Bar graphs are ideal for showing information that reflect quantities or the frequency of things, such as kinds of pets, number of children, or people's favorite brands. Bar graphs are frequently used to display data in science and are the first graphs that students learn to create. Follow the steps below to create bar graphs based on data in a data table.

Which detergent makes the best bubbles?

Detergent Brand	Size of Bubbles (cm)				Average Size of Bubbles (cm)
	Trial 1	Trial 2	Trial 3	Trial 4	
A	44.0	38.9	30.8	29.4	35.8
B	25.6	30.2	23.3	20.1	24.8
C	10.0	15.4	21.6	12.9	15.0

Step 1: Identify the variables

Independent variable (purposefully changed by the experimenter): *Detergent brand*

Dependent variable (changes with the independent variable and is measured):
Size of bubbles

Step 2: Determine the variable range

Subtract the lowest data value from the highest data value for the dependant variable.

Range of average bubbles: *35.8 cm - 15.0 cm = 25.8 cm*

Step 3: Determine the scale of the graph

Determine the numerical value for each grid unit that best fits the range of each variable.

Number of lines on graph: 36 (*y* axis)

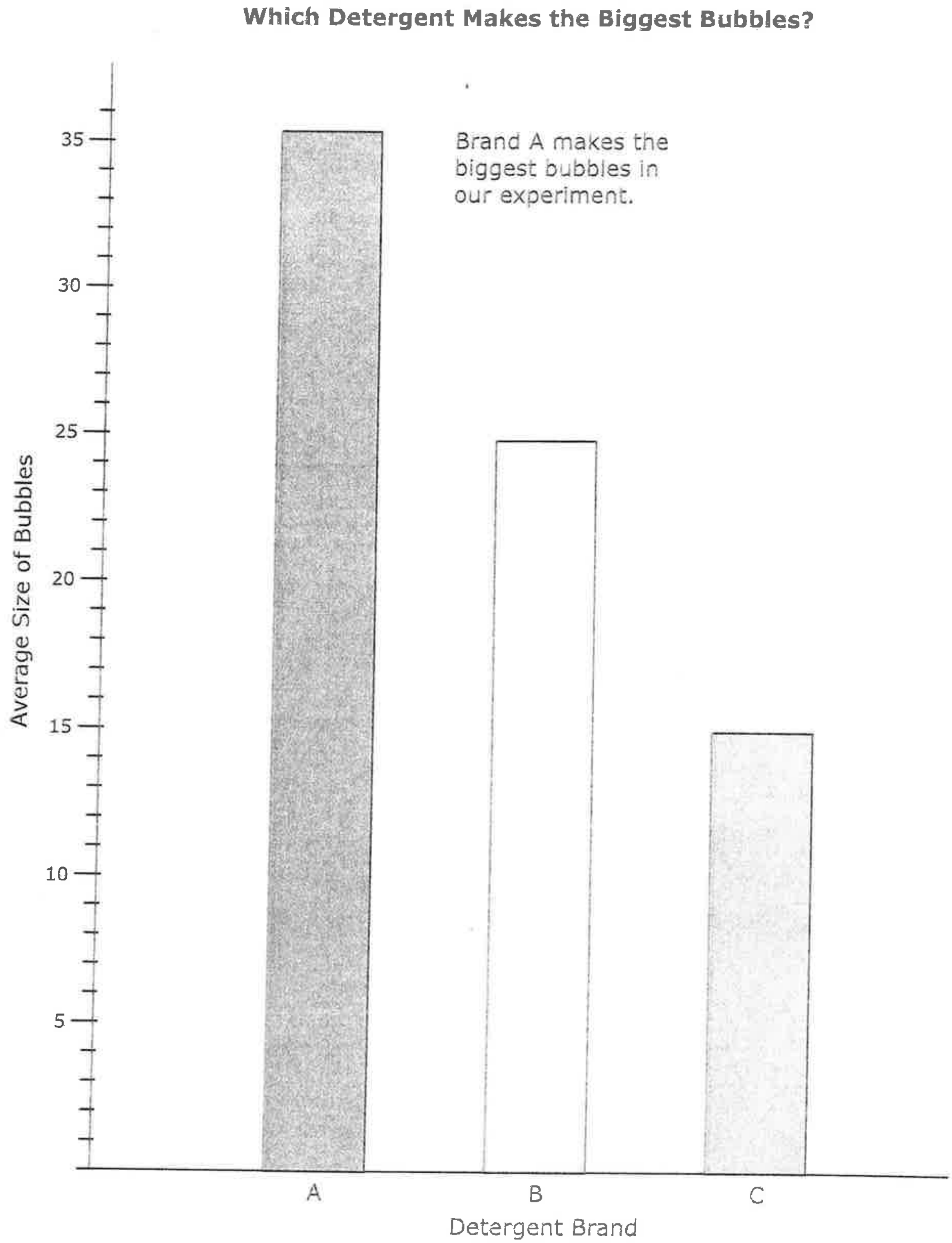
$$\frac{\text{Range}}{\text{\# of lines}} \quad \frac{25.8 \text{ cm}}{36 \text{ lines}} = .72 \text{ cm/line}$$ — *round to 1 cm/line*

Number of bars on graph: (*x* axis)
3 brands: evenly spaced

Step 5: Number and label the *y* axis, label the *x* axis, and title the graph

Step 4: Determine the data points and create the bar graph

(A, 35.8 cm) (B, 24.8 cm) (C, 15.0 cm)


Which Detergent Makes the Biggest Bubbles?
Brand A makes the biggest bubbles in our experiment.
Average Size of Bubbles
35
30
25
20
15
10
5
A
B
C
Detergent Brand

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Tutoring Three: Learning to Make Bar Graphs

Sample Data for a Bar Graph

Example 1: Pet Survey (GR 2–3)
Ms. Hubert's afterschool students took a survey of the 600 students at Morales Elementary School. Students were asked to select their favorite pet from a list of eight animal. Here are the results.

Lizard 25, Dog 250, Cat 115, Bird 50, Guinea pig 30,
Hamster 45, Fish 75, Ferret 10

Example 2: Bubble Sizes (GR 3–5)
One of Mr. Tongy's teams of students in an afterschool science class had the following bubble-sizes data in the Festival of Bubbles' activity, "Which Liquid Detergent Makes the Biggest Bubbles?"

Brand A: 44.0 cm, 38.9 cm, 30.8 cm, 29.4 cm
Brand B: 25.6 cm, 30.2 cm, 23.3 cm, 20.1 cm
Brand C: 10.0 cm, 15.4 cm, 21.6 cm, 12.9 cm

Example 3: pH of Substances (GR 5–10)
The following are pH values of common household substances taken by three different teams using pH probes. *Safety precautions in repeating this experiment include hooded ventilation, chemical-splash safety goggles, gloves, and apron. Do not use bleach, ammonia, or strong acids with children.*

Lemon juice 2.4, 2.0, 2.2; Baking soda (1 Tbsp) in Water (1 cup) 8.4, 8.3, 8.7; Orange juice 3.5, 4.0, 3.4; Battery acid 1.0, 0.7, 0.5; Apples 3.0, 3.2, 3.5; Tomatoes 4.5, 4.2, 4.0; Bottled water 6.7, 7.0, 7.2; Milk of magnesia 10.5, 10.3, 10.6; Liquid hand soap 9.0, 10.0, 9.5; Vinegar 2.2, 2.9, 3.0; Household bleach 12.5, 12.5, 12.7; Milk 6.6, 6.5, 6.4; Household ammonia 11.5, 11.0, 11.5; Lye 13.0, 13.5, 13.4; and Sodium hydroxide 14.0, 14.0, 13.9; Anti-freeze 10.1, 10.9, 9.7; Windex 9.9. 10.2, 9.5; Liquid detergent 10.5, 10.0, 10.3; and Cola 3.0, 2.5, 3.2

Teaching tip: *The pH scale is from 0 to 14. Have students make two data tables, one with the data as given and one with the pH scale 0 to 14 with the substances' average pH in rank order on the scale (Battery acid at the lower end and Sodium hydroxide at the upper end) or create a pH graphic organizer.*

Example 4: Automobile Land Speed Records (GR 5-10)
In the first recorded automobile race in 1898, Count Gaston de Chasseloup-Laubat of Paris, France, drove 1 kilometer in 57 seconds for an average speed of 39.2 miles per hour (mph) or 63.1 kilometers per hour (kph). In 1904, Henry Ford drove his Ford Arrow across frozen Lake St. Clair, MI, at an average speed of 91.4 mph. Now, the North American Eagle is trying to break a land speed record of 800 mph. The Federation International de L'Automobile (FIA), the world's governing body for motor sport and land speed records, recorded the following land speed records. (Retrieved on February 5, 2006, from http://www.landspeed.com/lsrinfo.asp.)

Speed (mph)	**Driver**	**Car**	**Engine**	**Date**
407.447	Craig Breedlove	Spirit of America	GE J47	8/5/63
413.199	Tom Green	Wingfoot Express	WE J46	10/2/64
434.22	Art Arfons	Green Monster	GE J79	10/5/64
468.719	Craig Breedlove	Spirit of America	GE J79	10/13/64
526.277	Craig Breedlove	Spirit of America	GE J79	10/15/65
536.712	Art Arfons	Green Monster	GE J79	10/27/65
555.127	Craig Breedlove	Spirit of America, Sonic 1	GE J79	11/2/65
576.553	Art Arfons	Green Monster	GE J79	11/7/65
600.601	Craig Breedlove	Spirit of America, Sonic 1	GE J79	11/15/65
622.407	Gary Gabelich	Blue Flame	Rocket	10/23/70
633.468	Richard Noble	Thrust 2	RR RG 146	10/4/83
763.035	Andy Green	Thrust SSC	RR Spey	10/15/97

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Tutoring Three: Learning to Make Bar Graphs

Checklist for a Bar Graph

Criteria	Self		Tutor	
	Yes	No	Yes	No
Is there a title?				
Are axes drawn so that the allotted space is well used?				
Are the independent variable(s) spaced evenly on the horizontal axis?				
Is the dependent variable axis subdivided with equal intervals?				
Are the axes named with the correct variables?				
Are units in parentheses ( ) after the variable, if applicable?				
Is the type of graph appropriate for the data?				
Are data plotted correctly?				
Are colors, textures, or other features used to make the graph easier to read?				
Is a key used if applicable?				

Learning to Make Line Graphs (Grades 5-8)

Students take the results, or data, from different experiments and learn to make line graphs.

Note: This is the last lesson in a series. Start with Interpreting Data from Birdfeeders, then Learning to Make Data Tables. You may want to review Learning to Make Bar Graphs if you feel it would help students understand line graphs.

Duration: Two 45-minute sessions

Learning Goals

- Analyze data from a data table
- Construct a line graph to represent data
- Understand line graphs and interpret data using line graphs

Materials Needed

- Notebook paper
- Pencil
- Clear ruler
- Graphing paper (1 cm x 1 cm preferred)

Preparation

- Review the lesson, printouts.
- Make copies as needed.

What to Do

- **Engage** students by asking them what they already know about line graphs, or asking them to show you a sample of any line graphs they have made. Or, review the **Sample Data for a Line Graph** or the data table they made in the previous lesson (Learning to Make Data Tables). Select one data set and ask students how they might represent the results in a line graph. Note what students understand and where they need to modify their thinking.
- **Explore** line graphs.
    - Review the **Guidelines for Making a Line Graph** and the **Checklist for a Line Graph**. Ask students to select an example from the sample data and create a line graph.
    - As students work, review any vocabulary associated with data representations. Watch for typical errors and help students learn to identify them, check their work, and correct errors independently.
- **Explain** the results. Ask students to explain how they organized the data in their line graphs. Review students' line graphs using the line graph checklist. If you feel that sufficient progress has been made, ask students to continue using other sample data sets to create additional line graphs.
- **Extend** learning if you have extra time. Ask students for ideas, or use school-day science lessons or the Internet to collect additional data for more line graphs. If you are familiar with Microsoft Excel®, teach students to create electronic spreadsheets with line graphs.

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Tutoring Four: Learning to Make Line Graphs

Guidelines for Making a Line Graph

The effect on increasing coils on the number of paperclips an electromagnet picks up.

Number of Coils	Number of Paperclips			Average Number of Paperclips
	Trial 1	Trial 2	Trial 3	
5	3	5	4	4
10	7	8	6	7
15	11	10	12	11
20	15	13	14	14

Step 1: Identify the variables

Independent Variable (purposefully changed by the experimenter): *Number of coils*
Dependent Variable (changes with the independent variable and is measured): *Number of paperclips*

Step 2: Determine the variable range

Subtract the lowest data value from the highest data value for each variable.
Range of paperclips: *14-4 = 10*
Range of coils: *20-5 = 15*

Step 3: Determine the scale of the graph

Determine the numerical value for each grid unit that best fits the range of each variable.

Number of lines on graph: 36 (*y* axis)

$$\frac{\text{Range}}{\text{\# of lines}} \qquad \frac{\text{10 paperclips}}{\text{36 lines}} = .28 \text{ paperclips/line}$$ — *round to .5 paperclips/line*

Number of lines on graph: 25 (*x* axis)

$$\frac{\text{Range}}{\text{\# of lines}} \qquad \frac{\text{15 coils}}{\text{25 lines}} = .6 \text{ coils/line}$$ — *round to 1 coil/line*

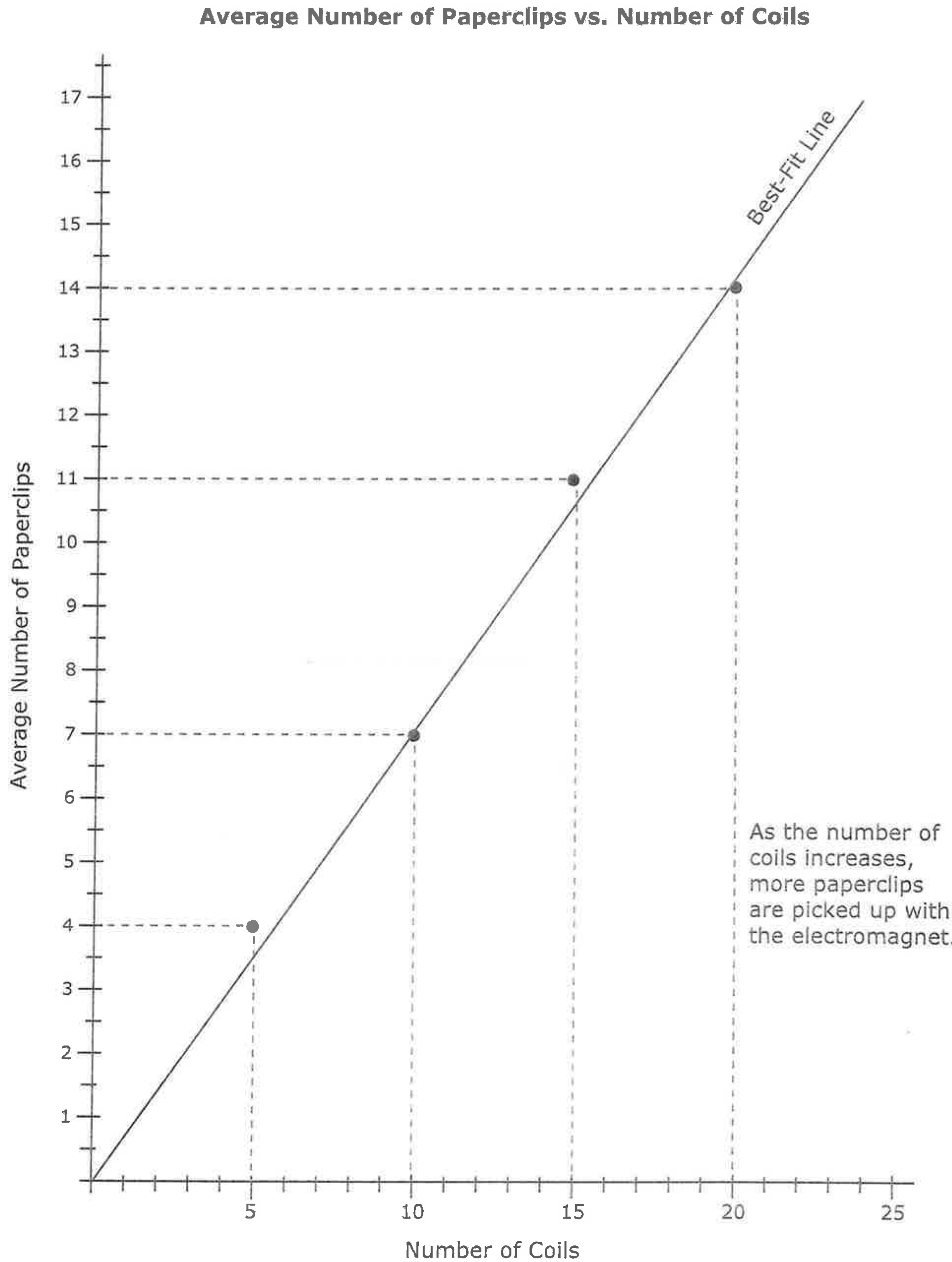
Step 4: Number and label each axis and title the graph

Step 5: Determine the data points and plot on the graph

(5, 4) (10, 7) (15, 11) (20, 14)

Step 6: Draw the graph

Draw a curve or a line that best fits the data points. Do not connect the dots.


Average Number of Paperclips vs. Number of Coils
Average Number of Paperclips
Number of Coils
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
5
10
15
20
25
Best-Fit Line
As the number of coils increases, more paperclips are picked up with the electromagnet.

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AFTERSCHOOL TRAINING TOOLKIT

Tutoring to Enhance Science Skills

Tutoring Four: Learning to Make Line Graphs

Sample Data for a Line Graph

Use these data to create data tables and line graphs following the Guidelines for Making a Line Graph and Checklist for a Line Graph. If you have already created data tables, use your completed data tables to make line graphs.

Example 1: Automobile Land Speed Records
In the first recorded automobile race in 1898, Count Gaston de Chasseloup-Laubat of Paris, France, drove 1 kilometer in 57 seconds for an average speed of 39.2 miles per hour (mph) or 63.1 kilometers per hour (kph). In 1904, Henry Ford drove his Ford Arrow across frozen Lake St. Clair, MI, at an average speed of 91.4 mph. Now, the North American Eagle is trying to break a land speed record of 800 mph. The Federation International de L'Automobile (FIA), the world's governing body for motor sport and land speed records, recorded the following land speed records. (Retrieved on February 5, 2006, from http://www.landspeed.com/lsrinfo.asp.)

Speed (mph)	Driver	Car	Engine	Date
407.447	Craig Breedlove	Spirit of America	GE J47	8/5/63
413.199	Tom Green	Wingfoot Express	WE J46	10/2/64
434.22	Art Arfons	Green Monster	GE J79	10/5/64
468.719	Craig Breedlove	Spirit of America	GE J79	10/13/64
526.277	Craig Breedlove	Spirit of America	GE J79	10/15/65
536.712	Art Arfons	Green Monster	GE J79	10/27/65
555.127	Craig Breedlove	Spirit of America, Sonic 1	GE J79	11/2/65
576.553	Art Arfons	Green Monster	GE J79	11/7/65
600.601	Craig Breedlove	Spirit of America, Sonic 1	GE J79	11/15/65
622.407	Gary Gabelich	Blue Flame	Rocket	10/23/70
633.468	Richard Noble	Thrust 2	RR RG 146	10/4/83
763.035	Andy Green	Thrust SSC	RR Spey	10/15/97

Example 2: Electromagnets—Increasing Coils (GR 3–5)
The following data were collected using an electromagnet with a 1.5 volt battery, a switch, a piece of #20 insulated wire, and a nail. Three trials were run. *Safety precautions in repeating this experiment include using safety goggles or safety spectacles and avoiding short circuits.*

Example 2 cont.

Number of Coils	Number of Paperclips
5	3, 5, 4
10	7, 8, 6
15	11, 10, 12
20	15, 13, 14

Example 3: Electromagnets—Increasing Batteries (GR 3–5)
The following data were collected using an electromagnet created with 1.5 volt batteries in series, a switch, a piece of #20 insulated wire, and a nail. Three trials were run with 10 coils. *Safety precautions in repeating this experiment include using safety goggles or safety spectacles and avoiding short circuits.*

Number of Batteries	Number of Paperclips
1	5, 4, 5
2	12, 10, 9
3	17, 15, 14
4	19, 23, 20

Example 4: Inclined Plane (GR 8–10)
The following data were collected using a photogate to measure the time that it takes for a ball to roll down an inclined plane. The angle of the plane was increased by using blocks (5 cm each) to increase the height of the plane from the floor. Four trials were run at each height. The same ball was released from the same starting point and was allowed to roll exactly 100 cm down the ramp. Create a data table, plot the data using a line graph, and draw the best-fit line or curve.

Height of Inclined Plane (cm)	Time (sec)
5	2.02, 2.10, 2.05, 2.00
10	1.85, 1.82, 1.67, 1.82
20	1.22, 1.29, 1.18, 1.25
30	1.00, 1.05, 1.07, 1.03

Example 5: Distance and Time (GR 8–10)
The following data were collected using a car with a water clock set to release a drop in a unit of time and a meter stick. The car rolled down an inclined plane. Three trials were run. Create a data table with an average distance column and an average velocity column, create an average distance-time graph, and draw the best-fit line or curve. Estimate the car's distance traveled and velocity at six drops of water. Describe the motion of the car. Is it going at a constant speed, accelerating, or decelerating? How do you know?

Time (drops of water)	Distance (cm)
1	10,11,9
2	29, 31, 30
3	59, 58, 61
4	102, 100, 98
5	122, 125, 127

AFTERSCHOOL TRAINING TOOLKIT
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Checklist for a Line Graph

Criteria	Self		Tutor	
	Yes	No	Yes	No
Is there a title? Is there a name and a date? Is the source noted?				
Are axes drawn so that the allotted space is well used?				
Is the independent variable scale appropriate for the data and the space allotted?				
Is the independent variable axis subdivided into equal intervals?				
Is the dependent variable scale appropriate for the data and the space allotted?				
Is the dependent variable axis subdivided into equal intervals?				
Are the axes named with the correct variables?				
Are units in parentheses ( ) after the variables?				
Are data plotted correctly?				
Are data points visible on graph—dark circle or other symbol?				
Is the type of graph appropriate for the data?				
Is the best-fit line or best-fit curve drawn?				
Are data connected with lines to show appropriate trends?				
Are colors, textures, or other features used to make the graph easier to read?				
Is a key used if applicable?				

Sink or Float?

You probably already know that some things will float in water and some will not. Do you know why that is? Sometimes the best way to find out if something will sink or float is just to try it--and that is exactly what you'll do in this experiment! Gather up some objects from around your house to test their sinking or floating abilities. Make sure all of the items you pick can get wet!

What You Need:

- a large container of water (or fill up a sink or bathtub)
- lots of small objects of different weights and materials (plastic, metal, wood, foil, Styrofoam)
- a few larger objects
- **"Will it Sink or Float" Worksheet**
- pen

What You Do:

1. Look at the objects you collected. Draw a picture of each one in the boxes on the left side of the worksheet.
2. Make a *prediction* about each object - do you think it will sink or float in the tub of water? (To make a prediction means to say what you think will happen.) Mark your prediction on the worksheet for each item (circle float or sink).
3. Drop the objects into the water one at a time. Watch what happens to each one. Did you predict correctly? Circle "float" or "sink" next to each object on the sheet to show the *results* of your experiment.

What Happened:

Even though some of your items seemed very light (things like a paperclip or a button), they still sank in the water. Some objects that might have seemed sort of heavy (like a wooden block) probably floated. That is because whether an object sinks or floats in water doesn't just depend on its weight or size. It also depends on its density. Density is a measure of how solid something is. All things are made up of tiny particles called molecules. If the molecules inside an object are very close together, the item is solid, or dense. If the molecules are farther away from each other, the object is less dense, or less solid. An example of a very dense item is a penny. A cork is less dense.

A penny, paperclip, or button sank because the materials they are made of (metal for a paperclip and penny, plastic for a button) had more density than water. (Their molecules are closer together than water molecules are.) A cork, piece of wood, or Styrofoam floated because those materials have less density than water. All the objects that were less dense than water floated in the water! Objects that were more dense than the water sank.

Will it Sink or Float?

1. Draw a picture of one item that you want to test in each box on the left.
2. In the box next to each picture, circle if you think the item will sink or float. This is your *prediction*.
3. Drop the object into the water and watch what happens. Was your prediction right? Circle sink or float to show what happened. This is the *result* of your experiment.

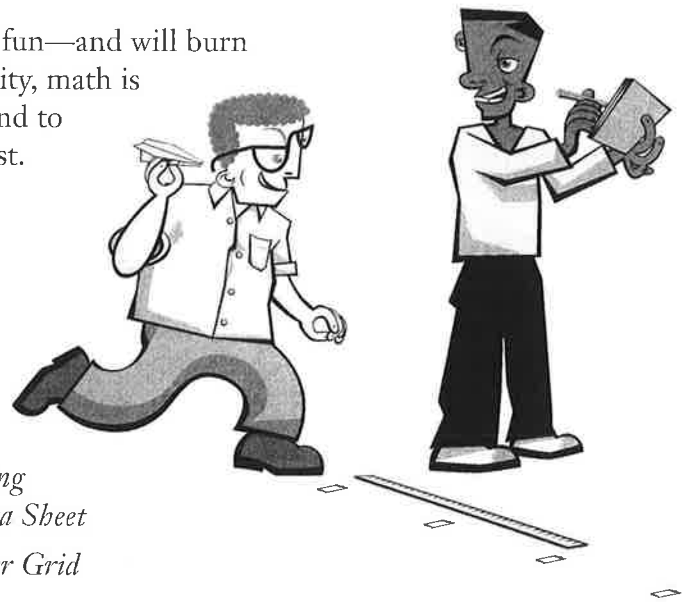
Draw a picture of each object.	What do you think will happen?	What happened?
	sink float	sink float
	sink float	sink float
	sink float	sink float
	sink float	sink float
	sink float	sink float
	sink float	sink float
	sink float	sink float

Leader Overview

ACTIVITY 20

Flying Things

Making and testing paper airplanes is great fun—and will burn off some energy on a rainy day. In this activity, math is used to make a paper airplane contest fair and to determine which airplane really flew the best.



Preparation and Materials

For each person, you will need:

- a few sheets of $8\frac{1}{2}$-by-11-inch paper (Reused is fine.)
- small paper clips, a pencil, and a ruler
- copies of *Folding Your Flying Thing*, *Testing Your Flying Thing*, and *Flying Things Data Sheet*
- 1-cm graph paper or a copy of *Centimeter Grid Paper*

For each pair of people, you will also need:

- a piece of string about 150 cm long
- a meterstick or a *Make-It-Yourself Meterstick*

To set up the testing ground where you will fly the planes, you will need:

- masking tape and a permanent marker (if your testing ground is indoors) or chalk (if it is outdoors)
- a meterstick or a *Make-It-Yourself Meterstick*

Use masking tape or chalk to mark the ground in 50-cm increments. Label each increment: zero cm (start line), 50 cm, 100 cm, and so on. Your testing ground should be at least 10 meters (1000 cm) long.

Planning chart

Folding flying things	10 minutes
Testing flying things	15–20 minutes

Explorer's Notebook

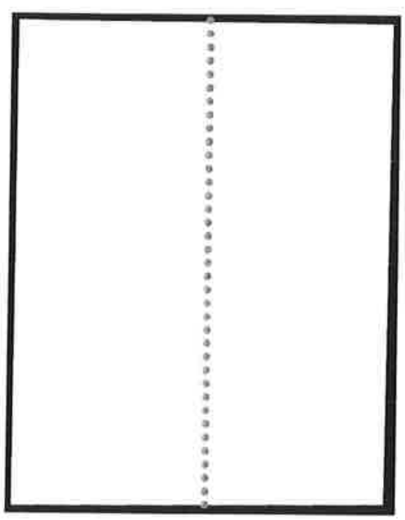
Folding Your Flying Thing

In the past two decades, paper airplane makers have introduced some improvements in paper airplane design. This paper airplane includes the *Nakamura lock*, which is named after the origami artist who invented it.

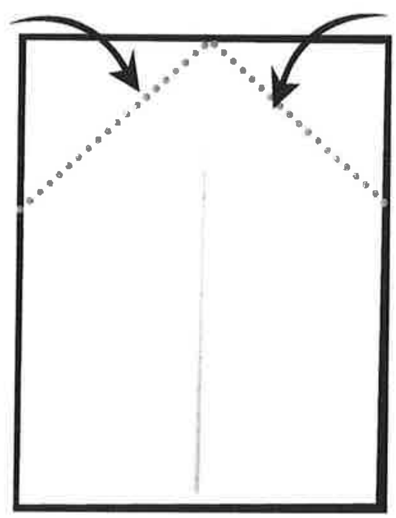
What Do I Need?

- a few sheets of $8\frac{1}{2}$-by-11 inch paper
- a pencil

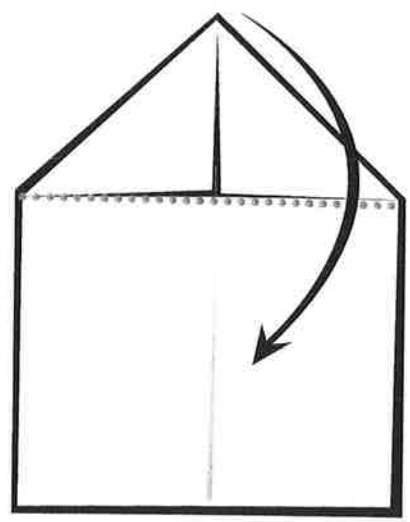
What Do I Do?



Step 1 Fold a sheet of paper in half lengthwise. Unfold it so that the crease makes a valley in the paper.

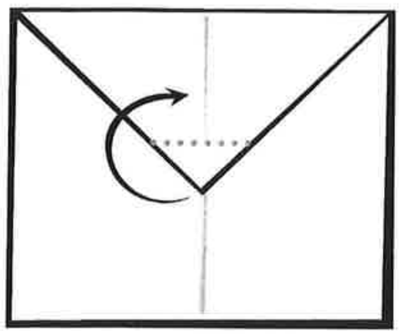


Step 2 Fold the top corners down to the center fold.

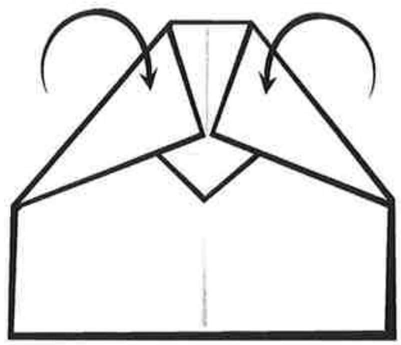


Step 3 Fold the tip down.

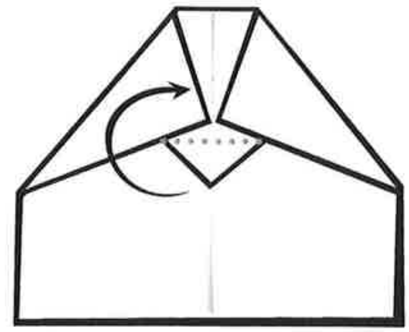
Folding Your Flying Thing (page 2)



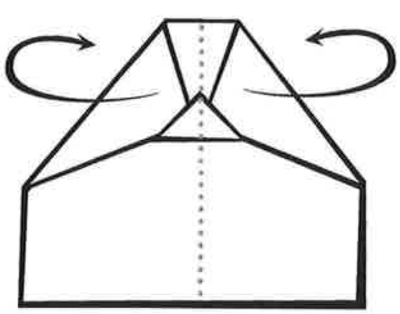
Step 4 Fold about 1 inch of the tip up, and then unfold it.



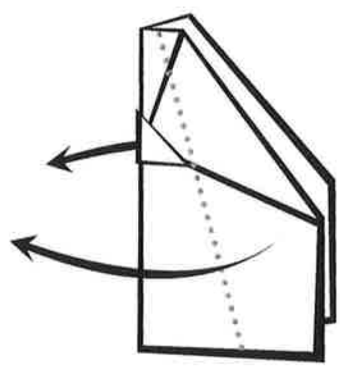
Step 5 Fold the top corners down to the center fold so that the corners meet above the fold in the tip. The top—the nose of the plane—should be blunt.



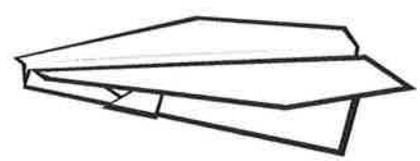
Step 6 Fold the tip up. This is the Nakamura lock.



Step 7 Fold the entire plane in half so that the lock is on the outside.



Step 8 Fold the wings down. You can choose how wide or narrow to make the wings.



Step 9 Write your name on your plane.

Testing Your Flying Thing

What Do I Need?

- a paper airplane
- a pencil
- small paper clips
- *Flying Things Data Sheet*
- a piece of string and a meterstick
- a partner

What Do I Do?

Step 1

Follow the given directions and make your plane

Step 2

If your plane doesn't fly well, make a few adjustments. This is known as *trimming* your plane. Here are some adjustments to try:

- If the plane dives into the ground, bend up the backs of the wings. A little bend goes a long way.
- If the nose of the plane rises first and then drops, the plane is stalling. Bend down the backs of the wings. Keep your adjustments small.
- If the nose is still rising, add a paper clip to the nose.
- Trim your plane, and practice throwing it until you're happy with how it flies.

Step 3

Your leader will tell you when it's time to test your plane. When it's your turn, throw your plane. Note where the nose of your plane lands, and mark that measurement on your *Flying Things Data Sheet*. If your plane lands between two marks, use a meterstick to measure how far the plane flew past the first mark.

Step 4

Test your plane three times. If you have time, do more trials. On your *Flying Things Data Sheet,* record how far your plane flew each time.

Explorer's Name ____________________

Flying Things Data Sheet

Use this data sheet to keep track of how well your plane flies.

What Do I Need?

- a pencil
- a ruler
- a sheet of grid paper
- a calculator

What Do I Do?

Step 1 For each trial, write down how the distance your plane flew in the chart below.

Trial Number	Distance Flown
1	
2	
3	
4	
5	
6	
Average	

Now, with the data you have collected, make your own data chart following the directions used for creating a data chart in the previous assignment you completed. You can make a bar graph that compares your data with a partner's data. In addition, a bar graph can be created showing the averages of all student data in the group.

1-CENTIMETER GRID PAPER