Unit: Intro Algebra: Graphing Data and the Coordinate Plane	***Date: Aug. 15, 2003***
Topic: Bouncing Tennis Balls (2-3 days)	Mr. Chao - 7th/8th Mid/High Math

Overview:	***Motivation:***
Students will bounce various tennis and racket balls, predicting and recording how fast they can bounce and catch them. They will graph the results on a coordinate plane. And then, they will compare their graphs with one another, analyzing how different variables affected their results.	Why do some things stretch when you pull them while others break? Why do some things bounce when you throw them, but other things shatter? Can you think of different things that bounce? How would you make them bounce more? How would you make them bounce less?

Objectives:

The students will:

1. develop the ability to collect data and record data in a table
2. make a graph to display data using correct labels and scale
3. recognize what varies in an experiment
4. name the independent and dependent variables in a problem
5. understand how temperature can change the elasticity of materials

Do Now:	***Resources/Materials:***
How many times do you think you can catch a tennis ball in two minutes? What about a racket ball? What about a frozen tennis ball? What about a frozen racket ball?	• Instruction worksheet • Data worksheets • Graphing worksheets • Tennis balls, two for each team of four students • Racket balls, two for each team of four students • Stop watch, one for each team of four students • Liquid Nitrogen, and a container to freeze the tennis balls and racket balls

Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597

Activities and Procedures:

Part I: Recording Data

- Students break into groups of four. Each group member is assigned a variable: *a, b, c, or d.*
- Introduce the experiment, and then have the students predict how many times they can bounce the various balls.
- Walk through the experiment and explain the sample data.
- Then have the students perform the experiment, switch roles with every new ball.

Part II: Graphing Data

- Every group member will be responsible for graphing a particular set of data.

Part III: Analyzing Data

- Have students compare their graphs with other groups. Then discuss why the graphs are different or why they are similar.
- Answer extension questions worksheet.

Directed Questions:

Why do we need to record the data?

Do you notice a pattern to your bounces?

Why is it better to have someone else count the bounces, and not the bouncer?

Why do we graph data? Does the graph show us anything we didn't see before?

What might have caused your graphs to look different than others?

Summary Activity:

Compare your data with another group. Do your graphs look the same? Why or why not? Did you expect your data to differ for the different types of balls?

In the experiment, what were the *variables*? Did any of the *variables* change? Were any of the *variables* the same?

What are some *variables* that you could change to alter his experiment?

How would you describe the speed of a bounced ball? Would you use one variable? Or would you have to combine two variables?

Homework:

How accurate was your prediction? In two-three sentences, explain why your prediction was or was not accurate.

Rating:

Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597

New York State Intermediate Mathematics Performance Standards:	***New York City Middle School Mathematics Performance Standards:***
Standard 4) Modeling/Multiple Representation Students use mathematical modeling/multiple representation to provide a means of presenting, interpreting, communicating, and connecting mathematical information and relationships. *Standard 5) Measurement* Students use measurement in both metric and English measure to provide a major link between the abstractions of mathematics and the real world in order to describe and compare objects and data. *Standard 7) Patterns/Functions* Students use patterns and functions to develop mathematical power, appreciate the true beauty of mathematics, and construct generalizations that describe patterns simply and efficiently.	• *M3a* Discover, describe, and generalize patterns, and represent them with variables and expressions • *M3c* Analyze tables to determine functional relationships • *M4a* Organize and display data • *M4d* Make conclusions and recommendations based on data analysis • *M4i* Make predictions based on experimental or theoretical probabilities • *M6g* Read and organize data on charts and graphs • *M7c* Use mathematical language to make complex situations easier to understand • *M7e* Show understanding of concepts by explaining ideas to others • *M8a* Data study • *M8e* Pure mathematics investigation

Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597

Assessment Suggestions:

- Compare graphs of various students, see if they all show the same relationships
- Look at graphs that look inaccurate, observe group members and roles.
- Have students compare graphs to one another
- Have Students design their own experiments and extensions

Modifications and extensions:

- Introduce another variable: bounce the objects on various surfaces.
- Students try to do something at a constant rate, such as turning pages in a book or tapping their feet.
- Plot additional data:
  - Pass a hand-squeeze around
  - How many left-handers do we have?

Contributors:

- Cornell University – CCMR group / RET Program
- Intermediate School 318, Brooklyn, NY
- National Council of Teachers of Mathematics

Additional Resources:

1. The template for this lesson: National Council of Teachers of Mathematics Lesson: http://illuminations.nctm.org/lessonplans/6-8/bouncing/index.html

2. Great book of Algebra Lesson Plans: Navigating through Algebra in Grades 6–8 http://my.nctm.org/store/Ecat/product.asp?ID=754

3. Extension activity on predicting patterns through hand-squeezes http://illuminations.nctm.org/swr/review.asp?SWR=175

4. Extension activity on graphing right and left-handed frequency on a coordinate plane http://illuminations.nctm.org/swr/review.asp?SWR=548

5. Great book on middle-school math concepts: Teaching and Learning Elementary and Middle School Mathematics, 4th Edition. Sheffield, Linda Jensen and Douglas E. Cruikshank. John Wiley & Sons : 2000.

6. Good math resource Book: Math on Call: A Mathematics Handbook. Kaplan, Andrew. Great Source Education Group: 1998 National Council of Teachers of Mathematics

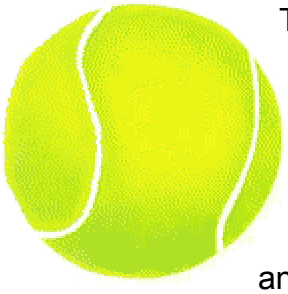
Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597

IS 318 Name:_____ – Class:____ – ID:_____
Mr. Chao, Mathematics August 13, 2003

How many times can you bounce and catch a tennis ball in two minutes?

In this lab, you will break into groups of 4. Each member will rotate among these four roles:

1) *Counter – Counts the number of bounces.*
2) *Bouncer – Bounces and catches the ball against the ground.*
3) *Timer – Keeps track of the ten-second intervals.*
4) *Recorder – Writes down and graphs the data.*



Tennis balls are lined with rubber on the inside. This makes it bounce. Rubber is a type of polymer that has a specific property that makes it elastic and bouncy.

In this experiment, we will work with two balls containing rubber. A tennis ball is lined with rubber, while a racket ball is completely rubber.

Will they bounce? Will one bounce higher than another? What happens if we freeze them? What about if we bounce them off of different surfaces?

Part I: Recording Data

A bounce is defined as dropping the ball from your waist. Work with a team of four people (including yourself). *The timer* keeps the time while *the bouncer* bounces and catches the ball. *The counter* counts the bounces, and the recorder writes down the data in the appropriate table.

Before you begin the trial, the bouncer should predict how many times he or she can bounce the ball in two-minutes. Write that prediction in the box on the bottom right of the data worksheet.

Each trial consists of a two-minute experiment, with the number of bounces recorded after every ten seconds. *The timer* calls out the time at ten-second intervals. When the time is called, *the counter* calls out the number of bounces that occurred during that ten-second interval. *The recorder* writes this count in the table.

The same process is followed by each person on the team, with the team members rotating roles, so that each person can collect a set of data. Look on the worksheet to see your roles. Make sure to fill in your names according to your roles.

Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597

All team members must bounce the ball on the same surface (e.g., tile, carpet, concrete) because differences in the surface could affect the number of bounces.

Part II: Graphing Data

The recorder adds up the number of bounces for each time interval to show the cumulative number of bounces, which means the total number bounces.

Then, graph the data on the graph worksheet. Graph time on the X-axis, going left to right. The graph is already prepared for the appropriate time increments.

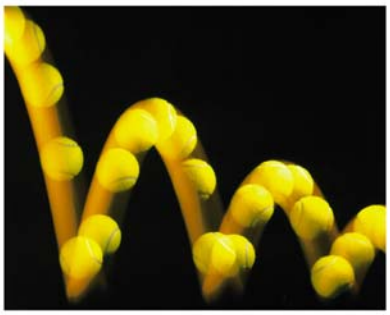
Then, look at your data for the cumulative number of bounces. Figure out an appropriate increment for the Y-axis so all your data fits on the graph and looks good. Graph your data for the number of bounces over two-minutes. Then, connect the points with straight lines.

Part III: Analyzing Data

Now that you've graphed your data, you can see how well your group bounced the tennis and racket balls. Look at your four graphs. Do they all look different? Why or why not?

What does the graph tell you? Look at the labels for both of the axes. One says "Cumulative Number of Bounces" and the other says "Time". This graph shows us the number of bounces over time. Or rather, it shows the speed in which you bounced the ball.

Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597



Extension Questions:

1) What were two things that changed with each trial?

_____

_____

2) What were two things that stayed the same with each trial?

_____

_____

3) What were some of the variables we used in this experiment?

_____

_____

4) How did the freezing affect the bounciness of the balls?

_____

_____

5) What are other things that we could graph?

_____

_____

Bonus) If Speed = *s*, Number of Bounces = *b*, and Time = *t*, can you write an equation relating all three variables?

_____

_____

Support for Cornell Center for Materials Research RET Program is provided through NSF Grant DMR-0317597