Lesson Activity

Title	**Barbie Bungee (75-80 minutes)**
ID Number	MS-M-A1
Sequence and Duration	• Lead In (15-20 minutes) • Activity (45-50 minutes) • Closure (10 minutes)
Age Level	Middle School
Essential Question	**What is the maximum number of rubber bands that will allow Barbie to safely jump from a height of 400 cm?**
Learning Objectives	• TSW collect data on the distance Barbie falls. • TSW graph the distance versus the number of rubber bands used to make the bungee cord. • TSW generate a line of best fit to determine the relationship between the distance and the number of rubber bands. • TSW extrapolate from their lines of best fit the number of rubber bands needed to drop Barbie safely from 400 cm.
Other Objectives	• TSW communicate with their group by contributing their vocal input. • TSW write down and graph data. • TSW contribute to a group discussion about extrapolating from a small set of data.
Key Terms	• Scatter plot • Linear relationship • Line of best fit • Extrapolate
Materials Needed	Per Class: • Extra bags of identical rubber bands in case of breakage, loss, etc., and for building the final bungee cords • Extra graph paper Per Team: • 15-20 rubber bands, all alike, handing out 12 to start • 1 Barbie doll or doll/action figure of a similar size (all teams should have figures of identical or similar masses) • 6-inch piece of masking tape • Meter stick or tape measure • Calculator Per Student: • Handout: Barbie Bungee Activity Sheet • One piece of unbroken spaghetti • One or two pieces of graph paper • Handout: Scatter Plots • Handout: Linear Relationships – Line of Best Fit worksheet
Lead In	12. Ask students if they've ever done a bungee jump, or know anyone who has. What do they think it's like to fall like that and be caught by a bungee cord? 13. If you have access to the internet, show students the bungee jump video clip at http://www.extremeworld.com/attractions/bungee_jump/video.aspx. You can also show the video of a group of South Pacific islanders' jumping ritual at http://news.nationalgeographic.com/news/2005/11/1109_051109_video_landdive.html. [Note: Preview videos prior to showing to class.] Have the students compare the two set-ups. How does what the villagers experience differ from

	what a bungee jumper experiences? 14. Ask, what are the properties of a bungee cord that make it the material of choice for this kind of activity? [E.g. its strength, its elasticity, its length] How might these properties affect the jumper's experience? [The stretchiness of the bungee, combined with its length, affect how far the jumper will fall. The stretchier the bungee is, the more it will extend when the jumper falls, and the further the jumper will fall. Likewise, the longer the bungee is, the further the jumper will fall.] 15. Tell students that each group is a bungee jumping company. A very rich potential client, Barbie, is shopping for the thrill of a lifetime, and she wants a bungee jumping company that is concerned with her safety but able to provide as much excitement as possible. Ask students what their companies will need to consider when preparing to serve this customer. [She wants a big thrill, so they should get her as close to the floor as possible, but for her safety she needs to be far enough from the floor that she doesn't hit it and get hurt or killed.] 16. The students' mission will be to run an experiment to test bungee cord lengths (made of rubber bands) and collect data, so that they can come up with a prediction about what length Barbie's bungee cord should be so she can drop safely, but thrillingly!, from a 400 cm height. They will need to discover the relationship between the number of rubber bands and the distance that Barbie falls.
Activity	31. Have students get into groups of 3 or 4. Hand out the Activity Sheets to each student and a Barbie and two rubber bands to each group. Read through the instructions together, allowing time for students to make their predictions on page 1, and ensuring that students understand the procedure before they begin. Focus especially on the reason for taking data for three trials at each length and averaging [to have as accurate a final number as possible]. 32. Show students how to make a slipknot with the rubber bands (see Activity Sheet) and how to wrap the first rubber band around Barbie's feet. 33. Hand out the remaining materials to each group. Make sure each group has a space from which to drop their Barbie without interfering with other groups. 34. Give students approximately twenty minutes to complete their data collection. Circulate among the groups to ensure that students are measuring distances properly and recording data accurately. 35. When students are done collecting data, they should compute averages from the three trials at each cord length, then plot the points on graph paper or the graph area provided. 36. Tell students that they are making a *scatter plot*. Hand out the Scatter Plot handout. Show students that a scatter plot is a *plot* (or graph) on which points are *scattered*. (That is, they're not connected with a line like a game of connect-the-dots!) Scatter plots are good for telling if there's a relationship between two variables. Sometimes the points make a pattern; if that happens, you can tell there's a relationship between them. Ask students if any of the graphs on the handout look like they have a pattern [the second and third plots]. Ask if they can come up with any pairs of variables that they would expect to show a relationship like this [e.g. shoe size and height; number of calories eaten and weight; age and number of gray hairs]. 37. If the points are randomly scattered on the graph, with no pattern, you can conclude that there is no relationship between the two variables. Which of the graphs looks like a plot of two variables with no relationship? [the first one] Ask students to come up with examples of pairs of variables that you would NOT expect to be related [such as shoe size and number of siblings; number of leaves on the ground and number of cars in the parking lot; typing speed and date of birth]. 38. When students have their points plotted, ask if they see a pattern. What is the

	pattern? [diagonal line] Is there relationship between the two variables? [yes] What is the relationship? [As one variable increases, the other increases as well.] When the students are all comfortable with seeing the relationship, tell them that there is a *linear relationship* between the two variables. A linear relationship is one in which the two variables are directly proportional to each other; if you double one variable, the other variable also doubles. This kind of relationship looks like a straight line. 39. Tell students that when there is a linear relationship between the two variables of a scatter plot, you can draw a *line of best fit* that approximates the relationship. The line of best fit is a straight line that falls as close to possible to all the data points; it may or may not go through any of the points students plotted. It is a best-guess representation of the data, and the equation of the line is a best-guess approximation of the relationship between the two variables. 40. Hand out pieces of spaghetti and the Linear Relationships - Line of Best Fit worksheet to students. Have them place the spaghetti on their graphs so that they find a place where it is as close to as many data points as possible. When they have placed it where they think it should go, have them trace the line it makes on their graphs (making sure their spaghetti strand is actually straight!). 41. They can then *extrapolate* (infer other values based on information they have) by projecting their line outward to solve for a value of 400 cm. They can do this by extending their line of best fit out to 400 cm on the x-axis. Students may need extra graph paper to do this. [Note: Students can work individually and come up with their own predictions, but have each group come up with a single prediction to test, in order to save time.] 42. Once the students have their predictions, have them construct their bungee cords for Barbie. 43. Bring all the Barbies and bungees to the 400 cm drop zone. The advisor or other adult should drop all the Barbies one by one while the students observe the results from below.
Closure	• Back in the classroom, discuss the results. Which group got Barbie closest to the ground without getting her *too* close? Were there any surprises? Did any groups vastly under or over-estimate the number of rubber bands that would be needed? What might account for sources of error in groups' predictions?
Informal Assessment	9. Monitor students for participation in activity and discussions. 10. Monitor students' understanding through one-on-one questioning and discussions.
Formal Assessment	• Completed Barbie Bungee data table and graph. • Completed line of best fit and prediction. • Constructed bungee cord for 400 cm drop.
Trouble Shooting	• Set up an area for the 400 cm drop ahead of time. 400 cm is 4 meters, which is approximately thirteen feet. Other heights can be used; choose your drop zone and set the height accordingly. • Try out the experiment yourself and try to determine how many rubber bands are needed for your height, so you will have a gauge for determining approximately how many rubber bands each group will need, and for informally assessing students' predictions.
Extension	• If students are getting the hang of recognizing patterns on a scatter plot, you can talk to them about positive and negative correlations. With a positive correlation, as one variable increases, the other increases as well. This is the case in the third plot on the Scatter Plot handout, and it will be the case for their own plots of rubber bands and distance fallen. With a negative correlation, as one variable increases, the other *decreases*. This is the case in the second plot on the Scatter Plot handout. Have students come up with pairs of variables they would expect to have a negative correlation, such as amount

	spent and amount saved for a given month's salary; temperature and number of people wearing winter coats; or amount of pollution in the air and number of stars you can see in the sky. • If students are comfortable with the idea of a linear relationship, you can introduce the concept of the *non-linear* relationship, where there is a pattern but it cannot be represented by a straight line. A non-linear relationship can be represented by a curved line, such as a parabola or sine function. An example of a non-linear relationship would be hours of sunlight vs. day of the year; the amount of sunlight does not keep increasing with every additional day, but rather increases and decreases as the year progresses. Have students try coming up with other pairs of variables that would have a non-linear relationship, such as amount spent advertising a product and amount of profit; amount of rain and number of flowers in a garden; or temperature and number of joggers in the park. • If students have a familiarity with graphing and algebra, you can have them try to determine their prediction mathematically rather than having them extend the line of best fit manually. See the high school version of this activity (HS-M-A1) for Line of Best Fit worksheet with the mathematical derivation.
Citation	National Council of Teachers of Mathematics, http://illuminations.nctm.org/LessonDetail.aspx?ID=L646

SEI Strategies Used

Preparation	Scaffolding	Grouping Options
☐ Adaptation of Content	☐ Modeling	☐ Whole class
☐ Links to Background	☒ Guided practice	☒ Small groups
☐ Links to Past Learning	☒ Independent practice	☐ Partners
☒ Strategies incorporated	☐ Comprehensible input	☒ Independent

Integration of Processes	Application	Assessment
☒ Reading	☒ Hands-on	☒ Individual
☒ Writing	☒ Meaningful	☒ Group
☒ Speaking	☒ Linked to objectives	☒ Written
☒ Listening	☒ Promotes engagement	☒ Oral

Arizona Math Standards Addressed	• S2C1: Understand and apply data collection, organization and representation to analyze and sort data, including identifying (grade 6, PO6) and interpreting (grade 7, PO7) a trend in data, formulating reasonable predictions based on a set of data (grade 8, PO7), evaluating the effects of missing/incorrect data on the results of an investigation (grade 8, PO 10), and identifying a line of best fit for a scatter plot (grade 8, PO 11). • S3C2: Describe and model functions and their relationships, by describing the rule used in a simple grade-level appropriate function (Grade 5-8, PO 1) and distinguishing between linear and non-linear functions (grade 8, PO 2). • S3C3: Represent and analyze mathematical situations and structures using algebraic representations. • S3C4: Analyze change in a variable over time and in various contexts.
Arizona Science Standards Addressed	• S1C2: Design and conduct controlled investigations. • S1C3: Analyze and interpret data to explain correlations and results; formulate new questions.

Barbie Bungee

Your mission today is to add some excitement to Barbie's life by preparing her for the bungee jump of a lifetime! Barbie will be jumping from a height of 400 cm at the end of the class, and you need to determine how many rubber bands will be needed for her to jump safely from this height. Experiment with the materials you have to determine the relationship between the number of rubber bands and the distance Barbie falls.

Read through all instructions before beginning your experiment!

Overview:

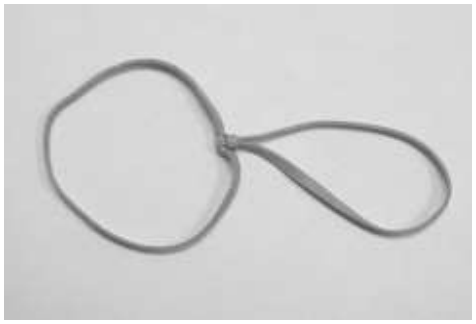
- Measure the distance Barbie falls with a bungee cord of two rubber bands, four rubber bands, six rubber bands, etc. Run three trials for each bungee cord length.
- Average the 3 distances for each cord length.
- Plot the averages on a graph of cord length vs. distance fallen.
- Figure out if there's a relationship between cord length and distance fallen.
- If there is, figure out what cord length (how many rubber bands) you'll need for a distance of 400 cm.

Prediction:

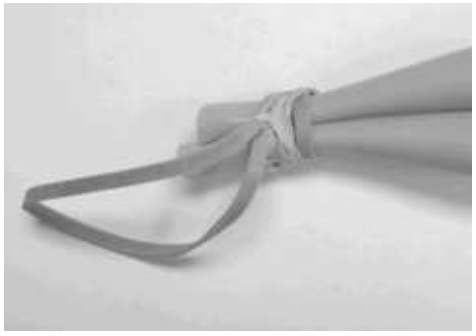
What is the maximum number of rubber bands that will allow Barbie to safely jump from a height of 400 cm? Write your prediction for the number of rubber bands that will be needed: _____

Instructions:

1. Tape a piece of masking tape to the wall at a height of about 6 feet. This is the line from which Barbie will "jump". Try to make sure the line is as level as possible.
2. Connect two rubber bands together with a slip knot.



3. Wrap the open rubber band tightly around Barbie's feet.



4. Attach another rubber band to the first with a slipknot – this now makes two rubber bands for Barbie's bungee cord.

5. One team member will hold the end of the cord to the line with one hand and "stand" Barbie on the line with the other. Member name: _____

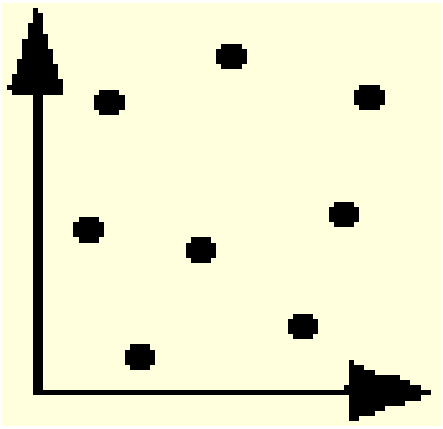
6. Let Barbie fall (head first) from the line while you hold onto the cord.
7. One team member should keep track of the lowest point Barbie reaches when she drops. Member name: _____
8. Another team member should measure the distance from this point to the line for each drop. Member name: _____
9. One team member should be in charge of recording this data for the team. Member name: _____
10. Repeat the drop for three trials at each bungee cord length. (Why?)
11. Add two rubber bands for each new cord length.
12. All team members should fill in the data sheet with the data recorded by the team recorder.
13. Make sure you record your data in centimeters!
14. Find the average jump distance for each bungee cord length.

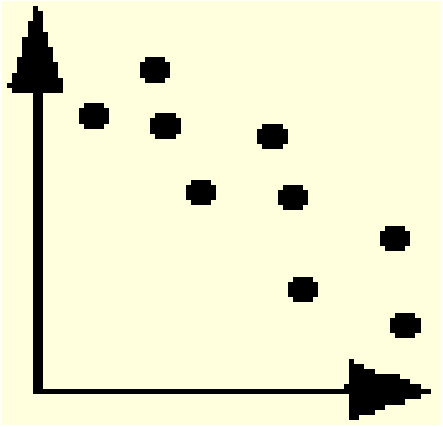
Barbie Bungee Data Sheet

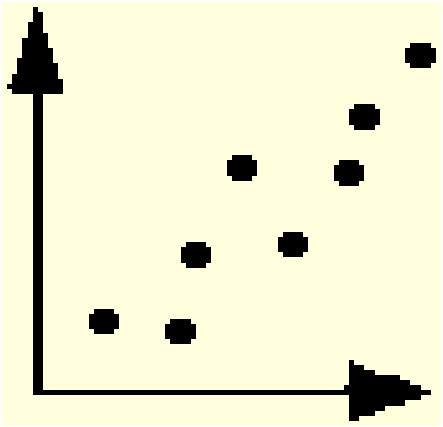
Number of Rubber Bands	Jump Distance – Trial 1 (cm)	Jump Distance – Trial 2 (cm)	Jump Distance – Trial 3 (cm)	Jump Distance - Average (cm)
2				
4				
6				
8				
10				
12				

15. Now create a scatter plot of your data. Make sure to indicate the scale of each axis, and to label your axes.

Scatter Plots

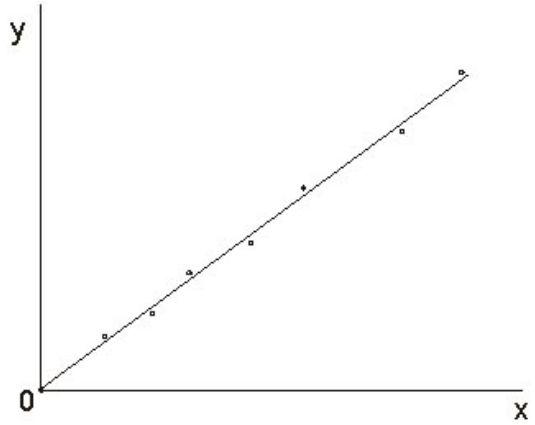






http://quest.nasa.gov/space/frontiers/activities/aeronautics/m.html

Linear Relationships – Line of Best Fit



A line of best fit comes as *close* as possible to *as many* points as possible on a scatter plot. The line of best fit is an *approximation*, or best estimate, of the relationship between the two variables represented by the scatter plot.

The line may or may not actually go through any of your plotted points, and it may or may not go through zero.

Line up your piece of spaghetti on your graph, so it gets as close as possible to your plotted points. When you have it where you want it, trace the line onto your graph. This is your line of best fit!

Mark the x-axis all the way out to 400 cm. If you need more paper, ask your advisor for another piece. Line a ruler up with your line of best fit and extend the line out to 400 cm. Find the point where the line reaches 400 cm on the x-axis. What is the y-coordinate of this point? _____

How many rubber bands (y) will you need to drop Barbie from a height (x) of 400 cm? Remember that she needs to clear the floor! Should you use a value of exactly 400 cm? Slightly less? Slightly more?

Write your prediction for the length of Barbie's bungee cord: _____
You'll be able to test your prediction with the class!