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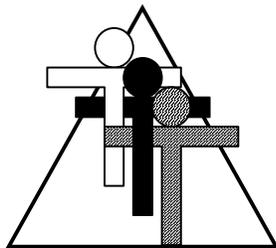
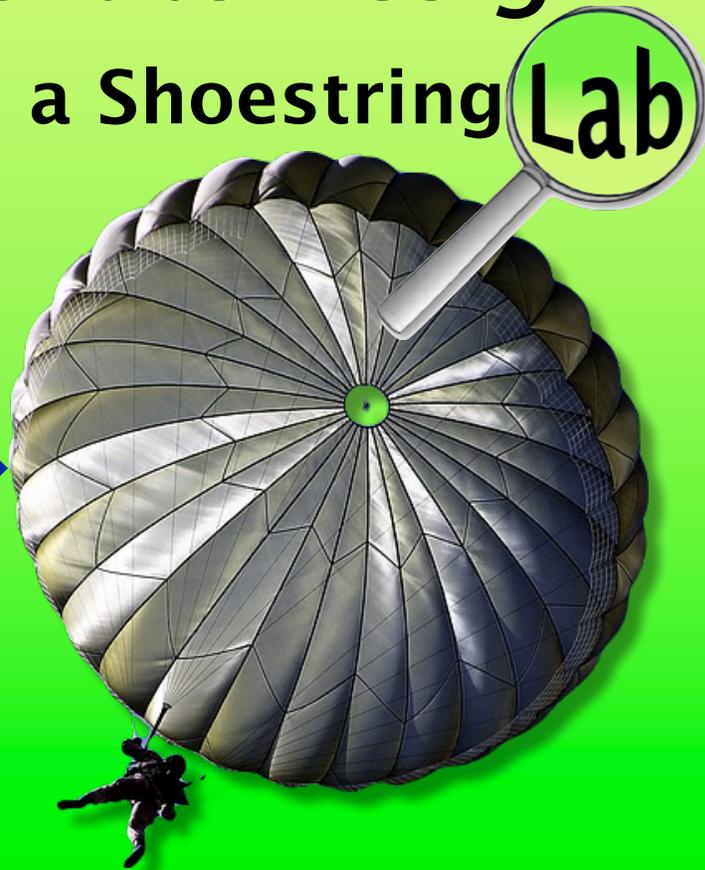
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Drop Zone Parachute Design

A STEM on a Shoestring **Lab**



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Brad Fulton

Educator of the Year



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- ◆ Consultant
- ◆ Educator
- ◆ Author
- ◆ Keynote presenter
- ◆ Teacher trainer
- ◆ Conference speaker

Known throughout the country for motivating and engaging teachers and students, Brad has co-authored over a dozen books that provide easy-to-teach yet mathematically rich activities for busy teachers while teaching full time for over 35 years. In addition, he has co-authored over 40 teacher training manuals full of activities and ideas that help teachers who believe mathematics must be both meaningful and powerful.

Seminar leader and trainer of mathematics teachers

- ◆ 2005 California League of Middle Schools Educator of the Year
- ◆ California Math Council and NCTM national featured presenter
- ◆ Lead trainer for summer teacher training institutes
- ◆ Trainer/consultant for district, county, regional, and national workshops

Author and co-author of mathematics curriculum

- ◆ Simply Great Math Activities series: six books covering all major strands
- ◆ Angle On Geometry Program: over 400 pages of research-based geometry instruction
- ◆ Math Discoveries series: bringing math alive for students in middle schools
- ◆ Teacher training seminar materials handbooks for elementary, middle, and secondary school

Available for workshops, keynote addresses, and conferences

All workshops provide participants with complete, ready-to-use activities that require minimal preparation and give clear and specific directions. Participants also receive journal prompts, homework suggestions, and ideas for extensions and assessment.

Brad's math activities are the best I've seen in 38 years of teaching!

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Sue Bonesteel, Math Dept. Chair, Phoenix, AZ

"Your entire audience was fully involved in math!! When they chatted, they chatted math. Real thinking!"

Brenda McGaffigan, principal, Santa Ana, CA

"Absolutely engaging. I can teach algebra to second graders!"

Lisa Fellers, teacher

References available upon request

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Thanks and happy teaching,

Brad 

I want...

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- b) Affordable staff development
- c) Ongoing staff development
- d) **ALL OF THE ABOVE!**

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Drop Zone

Parachute Design Project-Based Lab

Overview:

This highly adaptable investigation will engage students of many ages and levels. Options for primary, upper elementary, and middle school are included. This is a true STEM lab that incorporates the science, technology engineering, and math components. Common, inexpensive, and easily available materials make this an easy lab to teach yet it produces maximum learning and engagement in your classroom.

Procedure:

1. Explain that the students will need to design the most effective parachute. Ask them how they will determine the effectiveness of their parachute. Likely, they will suggest that the slowest rate of descent is the determining factor.
2. I begin by teaching my students about what I call the STEM Instructional Cycle. We begin with **research**. Ask students to share what they know about parachutes and how they work. You may wish to have them do some basic research using online or physical resources. This is an important component in the scientific process in general and in the STEM Instructional Cycle specifically.
3. Then show the students a basic parachute **design** as pictured on the following page. I Have the students **build** the basic parachute using a paper napkin, some string, four hole reinforcements, and a small plastic cup. The cup has four holes punched into the top near the rim. I make these holes with a paper punch.
4. Then they **test** this design. To do this, they can simply hold it high and let it drop. Alternatively, they can pack the chute by carefully folding it, winding the cords around it, and then tossing it aloft. As it descends, it tends to unfold and unfurl. One of the first questions you can pose is which system works the best? How many times

Materials

- Napkins
- Plastic shopping bags
- Coffee filters
- Tissue
- Paper clips
- Adhesive reinforcements
- Yarn
- String
- Thread
- Tape
- Small plastic cups
- Scissors
- Paper punch

Optional Materials

- Toy figurines
- Eggs or plastic eggs
- Stopwatch or smart phone

did the chute open when tossed in the air? Older students can quantify this as a percent. Does it unfurl safely 100% of the time?

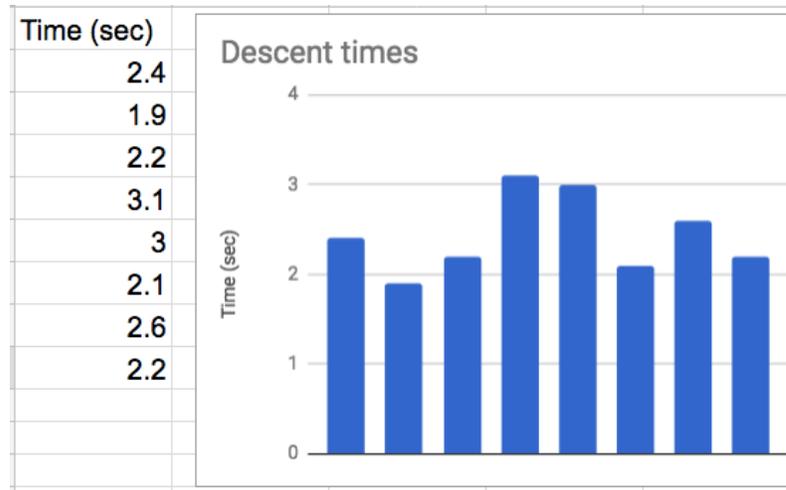


The basic parachute design

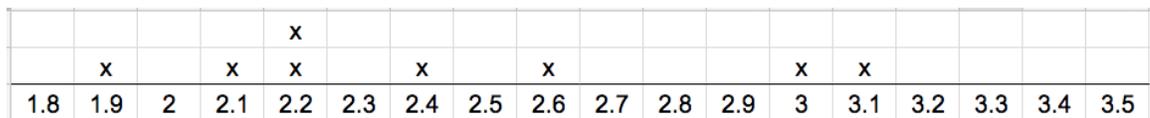
5. This transitions students into the fifth phase of the STEM Instructional Cycle: **Evaluation**. How well does their parachute design work? Do all the parachutes perform the same? Why or why not? What is it about some of them that makes them perform differently?

You may ask that upper elementary or middle grade students time the descent of their chutes. This data can then be represented graphically. A bar graph or line plot is appropriate, as is a box plot with middle grades. Then the data can be analyzed for range, median, mode, and mean.

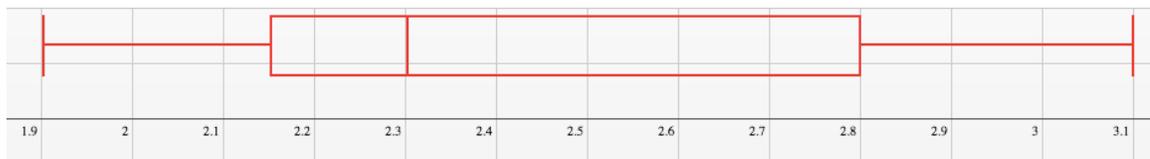
Your students can make graphs by hand or incorporate technology using graphing software. Here is a bar graph of eight data points made using Google Sheets.



Here the same data are represented on a line plot using Google Sheets.



And here is a box and whisker plot using Desmos graphing software.



- Next they move to the sixth stage of the cycle: **Improvement**. Ask them what they noticed about the performance of the parachutes? What can they do to make a more effective parachute? They may suggest a bigger or lighter chute, longer or shorter strings, lighter strings, and so on.
- This brings them back to the beginning of the STEM Instructional Cycle. They are doing **research** using all the parachute examples. They can also do more research online if you wish. Then they **design** their new parachute. You may have them sketch their ideas on blank paper or use the activity sheets that accompany this handout. There are two versions. One is for younger students, and the other is suited to more advanced learners.

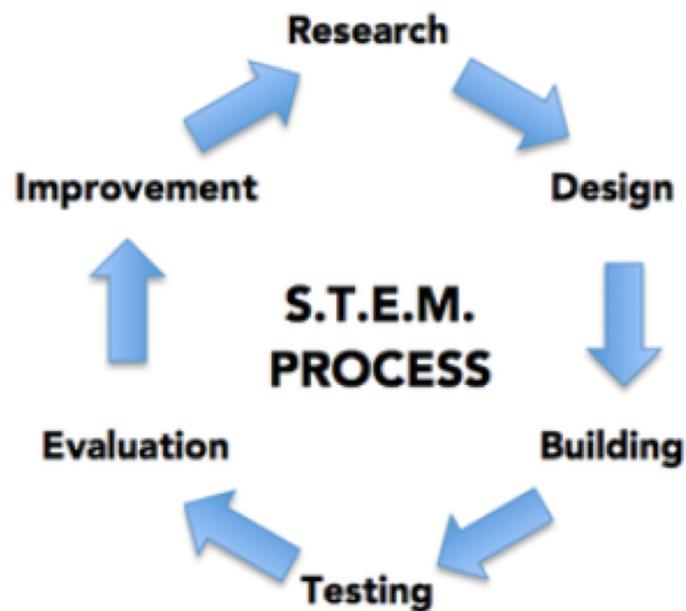
I require my middle school students to label all parts of their sketch and include metric measurements. Sometimes I have them trade their designs with another team. Thus they have to make their design detailed enough so that the new team can build it correctly.

If you want older students to incorporate technology, they can create their designs using any drawing program or auto cad software such as Google Sketchup.

- Next, students **build** their parachutes designs as they go back through the STEM Instructional Cycle. You can have them continue as long as time allows. This project can be implemented in one day or extended up to a full week of project-based instruction.

9. At this point, you can provide students with a variety of materials and challenges. Allow them to try using other materials for the parachute itself: plastic bags, coffee filters, tissue paper, and so on. They can substitute string, yarn, or thread for the parachute cords. This allows students to compare the effects of variables in the experiment. Students can compare the effect of the area of the parachute to its descent rate. Elementary students can measure the area of square or rectangular chutes while middle grade students calculate the area of circular chutes using $A=\pi r^2$.

The STEM Instructional Cycle:



Here are some challenges sorted by grade levels.

10. Primary: Grades K-2:

- a. Have students measure the effectiveness of their parachutes by having them drop them in pairs. The slower of the two chutes moves on to the next round until the slowest chute in the class is found. This allows them to “time” them without needing to know how to read or use a stopwatch.
- b. Students can compare different parachutes to find which materials and which designs perform better.
- c. Students can be asked to analyze the results by classifying how paper chutes perform compared to plastic chutes, yarn vs. string vs. thread, and so on.
- d. Students can put a figurine of a person or animal in the cup and try to land it safely on a target.
- e. Primary students may need assistance building their parachutes. If they have difficulty tying knots, the strings could be taped to the chute and to the cup.

11. Upper Elementary: Grades 3-5:

- a. Students should be required to attend to a higher degree of precision than primary learners. They may be able to use a timer to determine the slowest descent rate. If not, they can compare them as they did in the primary version. Get in groups of three to five and find the best performing parachute.
- b. If students can use a timer, they can perform multiple drops of their parachute. Have them time ten drops and graph the results. Then they can then analyze the data to determine a high performing chute. They can also look for the range, median, mode, and mean of the data.
- c. Put students in teams of four and have them study one variable such as the area of the chute. They then make sure all other factors of the parachute design are the same. Make sure all chutes are dropped from the same height. They can analyze the effect of this variable and present their findings to the class in person or submitted through a Google Doc or Google Slides presentation.

12. Middle grades: 6-8:

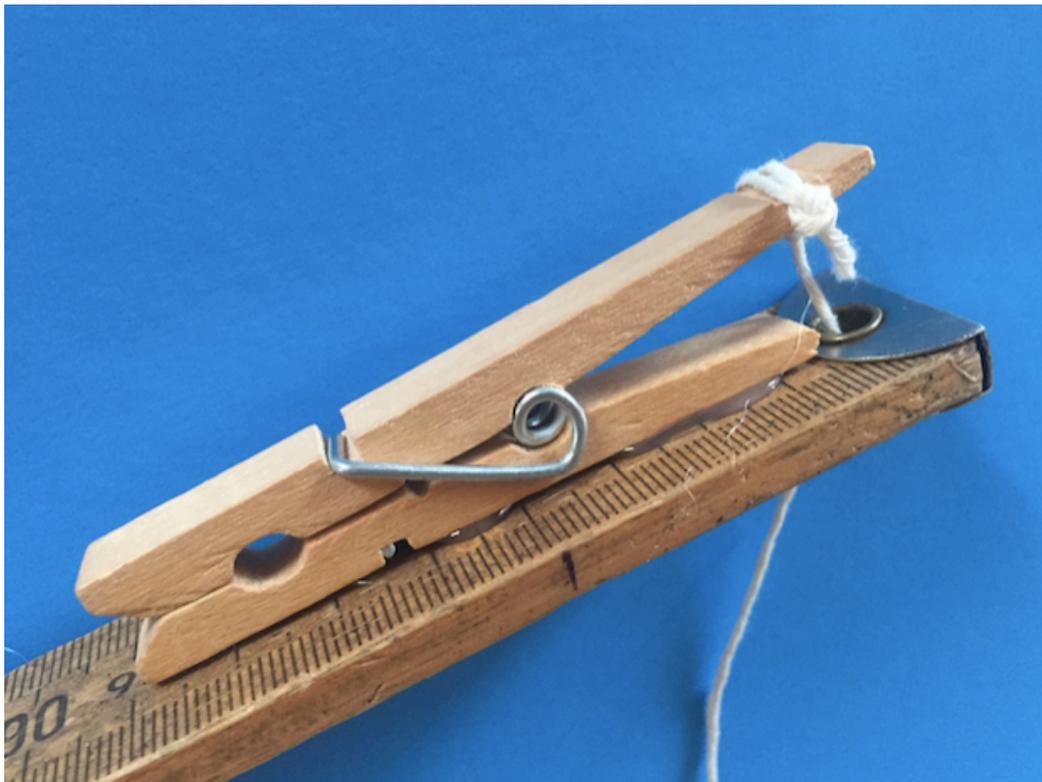
- a. Students should be held to all the standards of the elementary challenges and can handle a greater degree of precision in their measurements. They also can find averages of greater amounts of attempts such as 20 or 30.
- b. Students can work with circular parachutes and calculate the areas using the formula for a circle: $A=\pi r^2$. This data can then be analyzed using a scatterplot in which the x-axis – the independent variable – is the area of the chute and the y-axis – the dependent variable – represents the descent times. They can study the graph to find correlation between the bivariate variables.
- c. You can use the parachute as a component of the classic egg drop competition. Can they land an egg safely? You may wish to have them use a plastic egg.

- d. Students can apply their discoveries and understanding to our goal of landing on other planets. Why wasn't a parachute used in the moon landing? (Because there was no atmosphere, a parachute would have no effect.) How would a parachute perform on Mars? (Mars has an atmosphere of carbon dioxide, but it is much less dense than our own nitrogen/oxygen atmosphere. For that reason, a very large parachute would be required and would have limited efficiency.)

There is a wonderful YouTube video of a hammer and feather being dropped on the moon by Apollo astronaut David Scott.

<https://www.youtube.com/watch?v=KDp1tiUsZw8>

- e. Students will likely build more successful designs in middle school than in younger grades. Often they also will be more willing to improve and redesign their models.
- f. It will be more critical in the upper grades for students to standardize their testing and data. I wanted to drop all parachutes from the exact same height, and I wanted that to be higher than I could reach. Though I have a ten-foot high ceiling in my classroom, I didn't want my students to stand on chairs, desks, or ladders. I glued a clothes pin to the end of meter stick as shown and ran a string through a hole to trigger the drop. The meter stick allows my students to drop their parachutes from the full 10' height of the ceiling.



Notice that I trimmed one arm of the clothespin by the hole in the meter stick.

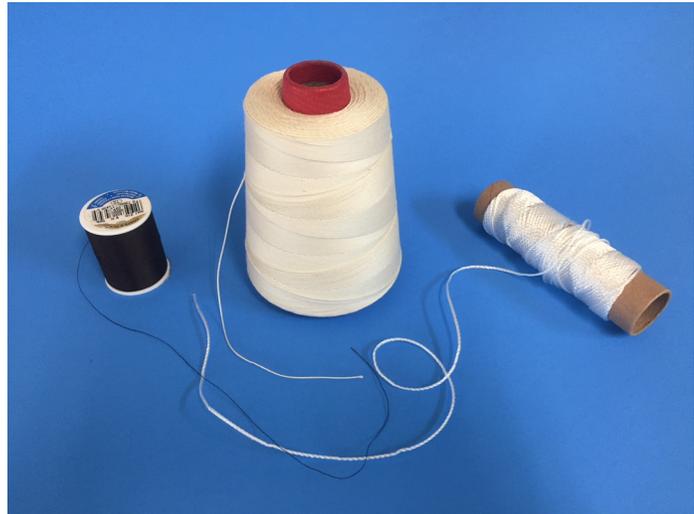


Extension stick with a parachute loaded for a drop.

13. Here are illustrations of some of the easily available and inexpensive materials that can be used in this lab along with pictures of the assembly of the basic parachute.



Adhesive reinforcements



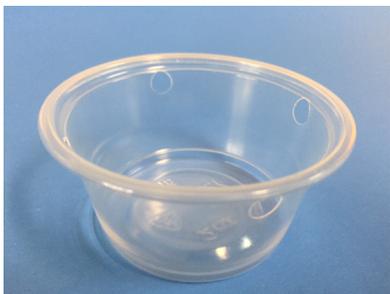
Thread, light string, and heavy string. Yarn or cordage can also be used.



Adhesive reinforcements are used to strengthen the corners where the strings attach. Younger students who cannot tie knots can tape the strings to the chutes.



Coffee filters, scissors, various cups, and napkins. Plastic shopping bags, tissue paper, and plastic wrap are other options. Paper clips can be used to attach the cup to the strings.



The cup has holes punched to attach the strings. Toy figurines can ride in as passengers in the basket.

14. Students have many options for modifying and improving their design. They can vary the type of string and the length of the string. They can experiment with the type of parachute material, the shape of it (circular vs. square), and the size (area). They can also change the cup or tie the strings directly to a toy figurine. Paper clips can be tied to the lower ends of the strings and attached to the holes in the cup.

Students may also notice that their napkin has two layers as shown below. The chute material will weigh half as much if only one layer is used.

Allowing students to experiment in this way helps them understand the importance of working with variables and controls in the scientific process.

variable — any component of an experiment that can be changed to affect the outcome.

For example, changing from a napkin to a coffee filter will likely affect the performance of the chute. However, changing the color would not.

control — any variable that is held constant between two experiments.

If students change the size of the parachute *and* the type of string and the chute performs better, they won't know which variable caused this. For this reason, we control all factors and study one variable at a time.



15. On the following pages are some planning guides you may wish to use with your students. The first one is for younger students and the second is for more advanced learners.

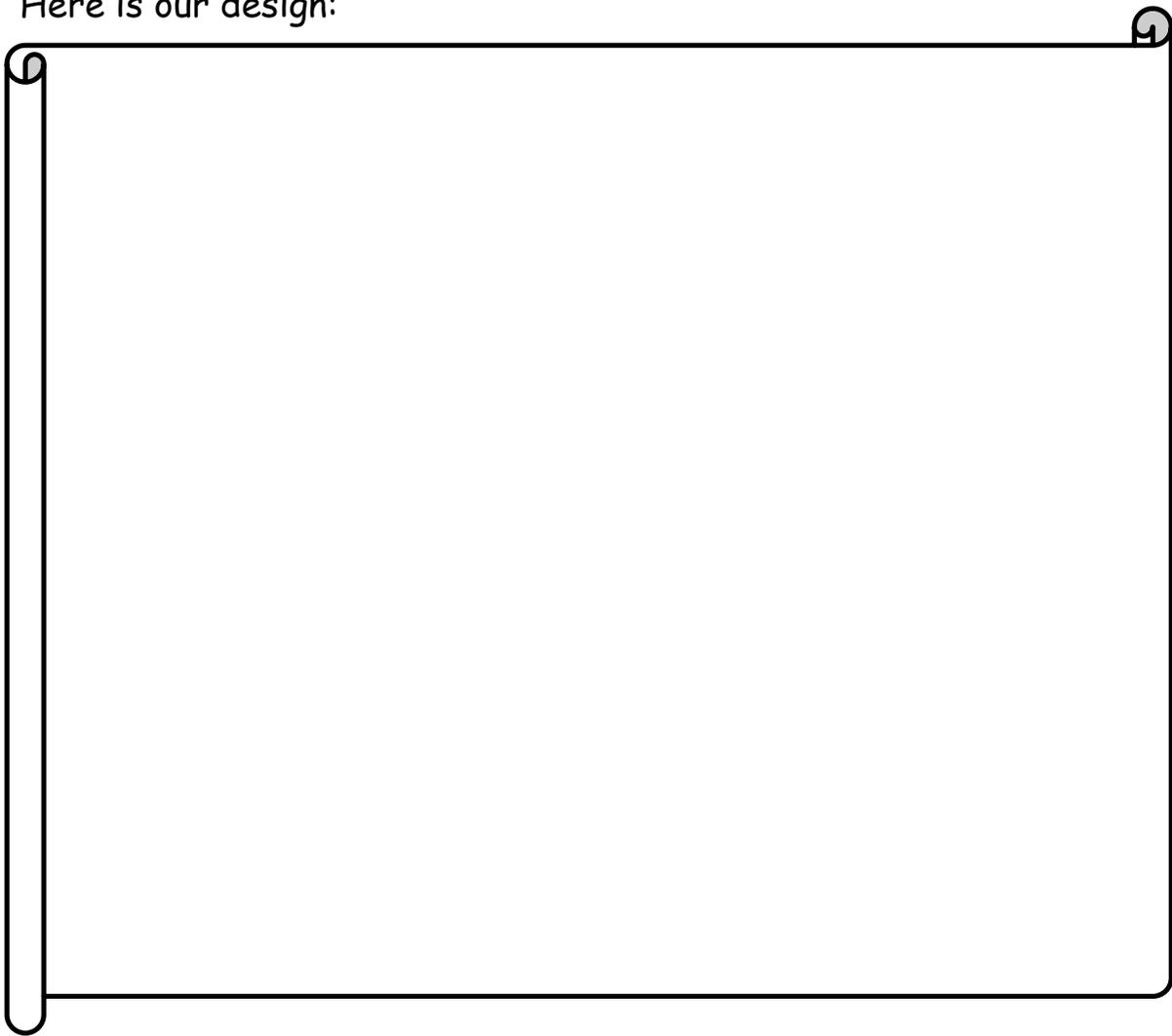
Parachute

Name _____

Planning Sheet

Here is what we know about parachutes:

Here is our design:

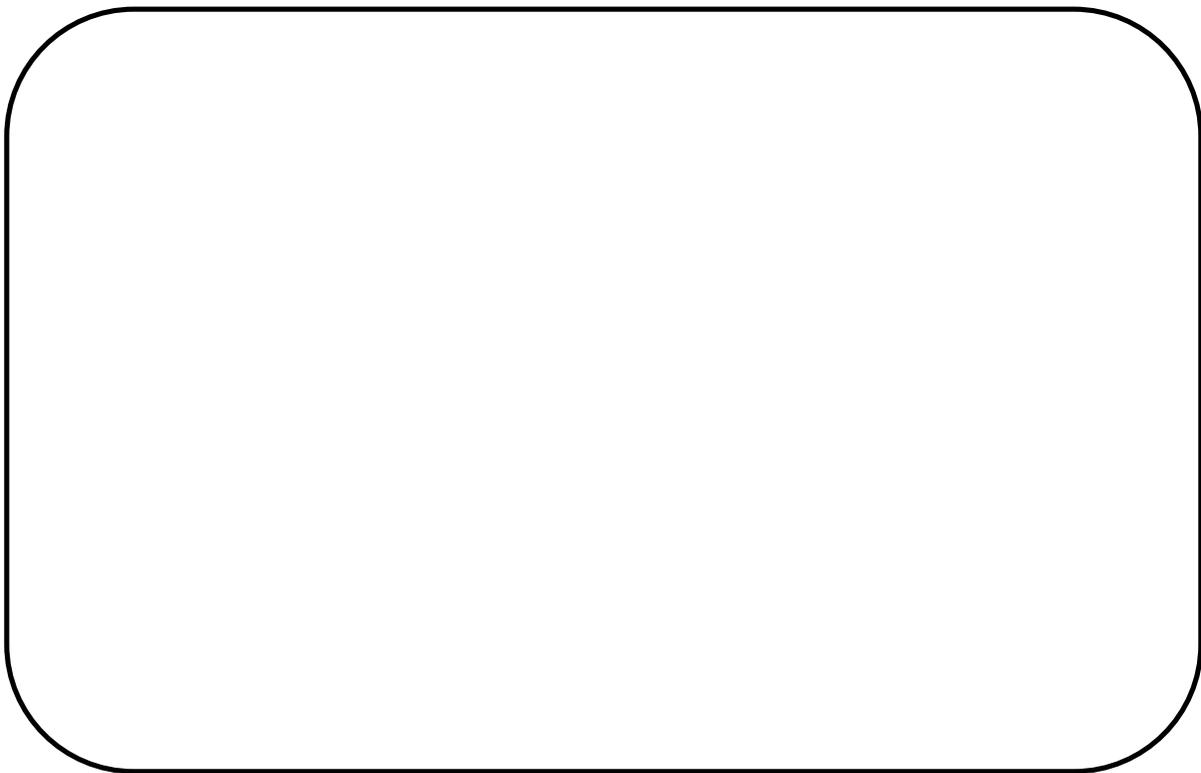


Think Sheet

Name _____

Research: What will make your parachute work the best?

Design: Draw a detailed plan of your parachute here. Label all the parts. Could someone else build this if they had your drawing?

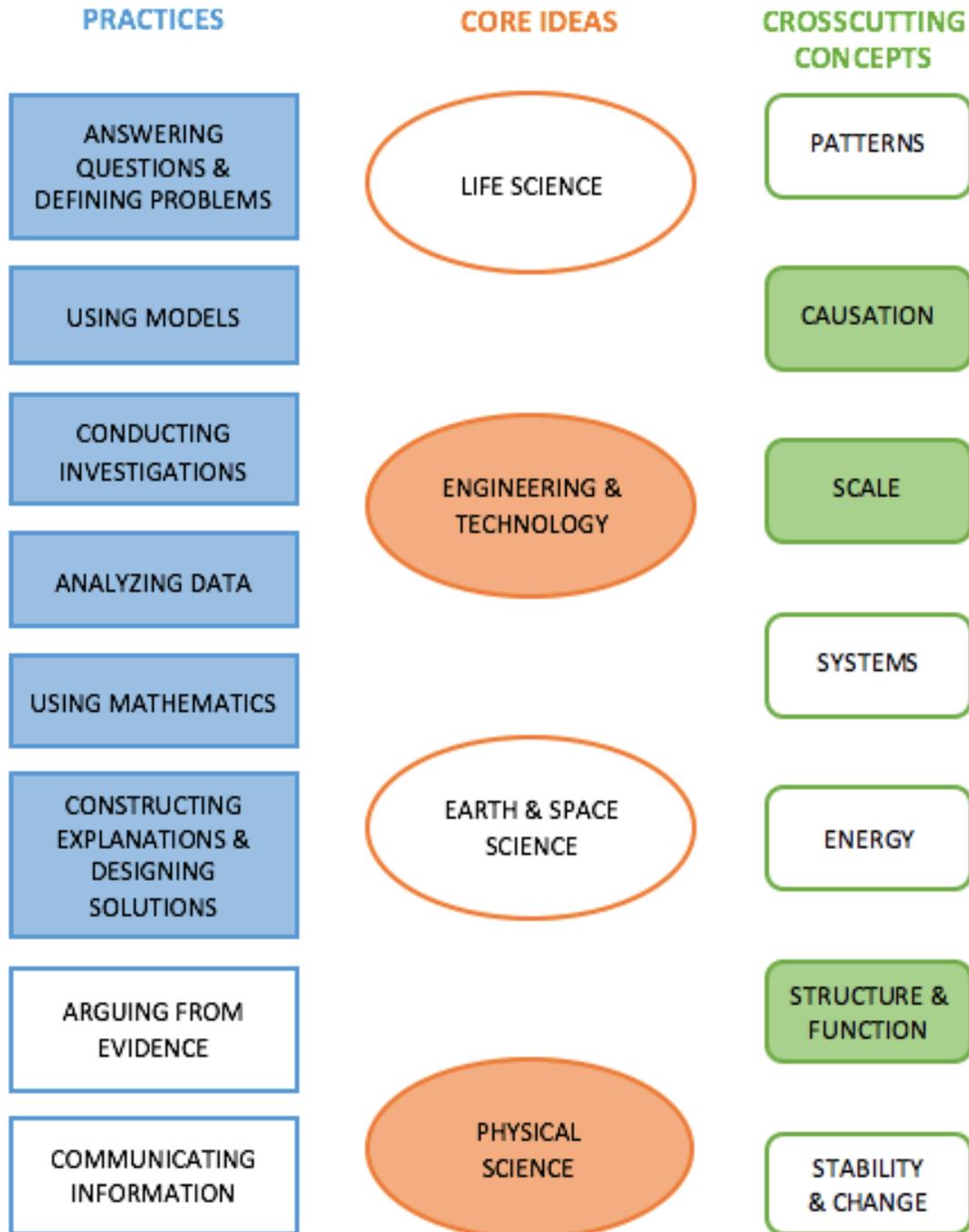


Now **build** your parachute and **test** it.

Evaluate and **Improve:** How well did it work? How will you improve your parachute?

The Next Gen Connection:

Colored shapes indicate the regions that are most strongly addressed in this activity.



The Common Core Connection:

In primary grades, students can compare the descent rates of variously shaped parachutes. For example, even kindergarteners can observe how a circular chute performs alongside a square chute of a similar size. They can even count the number of wins circular chutes have compared to square or triangular ones.

Third Grade:

CCSS.MATH.CONTENT.3.MD.C.5

Recognize area as an attribute of plane figures and understand concepts of area measurement.

CCSS.MATH.CONTENT.3.MD.C.5.A

A square with side length 1 unit, called "a unit square," is said to have "one square unit" of area, and can be used to measure area.

CCSS.MATH.CONTENT.3.MD.C.5.B

A plane figure which can be covered without gaps or overlaps by n unit squares is said to have an area of n square units.

Fourth Grade:

CCSS.MATH.CONTENT.4.MD.A.1

Know relative sizes of measurement units within one system of units including seconds.

CCSS.MATH.CONTENT.4.MD.A.3

Apply the area and perimeter formulas for rectangles in real world and mathematical problems.

CCSS.MATH.CONTENT.4.MD.B.4

Make a line plot to display a data set of measurements in fractions of a unit ($\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$).

Fifth grade:

CCSS.MATH.CONTENT.5.MD.B.2

Make a line plot to display a data set of measurements in fractions of a unit ($\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$).

Sixth grade:

CCSS.MATH.CONTENT.6.SP.A.1

Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.

CCSS.MATH.CONTENT.6.SP.A.2

Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

CCSS.MATH.CONTENT.6.SP.A.3

Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.

CCSS.MATH.CONTENT.6.SP.B.4

Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

CCSS.MATH.CONTENT.6.SP.B.5

Summarize numerical data sets in relation to their context, such as by:

CCSS.MATH.CONTENT.6.SP.B.5.A

Reporting the number of observations.

CCSS.MATH.CONTENT.6.SP.B.5.B

Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

CCSS.MATH.CONTENT.6.SP.B.5.C

Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.

CCSS.MATH.CONTENT.6.SP.B.5.D

Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered.

Seventh grade:

CCSS.MATH.CONTENT.7.G.A.1

Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

CCSS.MATH.CONTENT.7.G.B.4

Know the formulas for the area and circumference of a circle and use them to solve problems.

CCSS.MATH.CONTENT.7.SP.A.1

Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

CCSS.MATH.CONTENT.7.SP.B.4

Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.

Eighth grade:

CCSS.MATH.CONTENT.8.SP.A.1

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

CCSS.MATH.CONTENT.8.SP.A.2

Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

CCSS.MATH.CONTENT.8.SP.A.3

Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept.

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You can also find many free and inexpensive resources on my personal website, www.tttpress.com. **Be sure to subscribe to receive monthly newsletters, blogs, and FREE activities.**

Similar *S.T.E.M. ON A SHOESTRING* activities include:

- *Vibrobots* - Use inexpensive electric toothbrushes to make wiggly robots. Then use physics and math to analyze their speeds.
- *3-2-1 Launch: Catapult Design Lab* - This highly adaptable investigation will work with students of all ages and integrates math from primary grades through high school algebra. A fully inclusive S+T+E+M lab!
- *Slime Time* - A gooeey lab involving Non-Newtonian fluids. Get the PowerPoint too!
- *Ramp Races* - An engaging and exciting way to teach students the principles of physics: forces, motion, speed, friction, and more!
- *Invisible Ink Lab* - Make hidden messages appear using the principles of chemistry and simple kitchen ingredients

Feel free to contact me if you have questions or comments or would like to discuss a staff development training or keynote address at your site.

Happy teaching,

Brad