Lesson Title	Parachutes & Surface Area
Length of Lesson	100 minutes
Created By	Emily Burtnett
Subject	High School Math topics
Grade Level	9-12th
State Standards	2a,
DOK Level	2
DOK Application	Represent data from geometric and real-world contexts with expressions, formulas, tables, charts, graphs, relations, and functions.
National Standards	Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships. Use visualization, spatial reasoning, and geometric modeling to solve problems. Draw and construct representations of two- and three-dimensional geometric objects using a variety of tools. Use geometric models to gain insights into, and answer questions in, other areas of mathematics. Develop and evaluate inferences and predictions that are based on data.
Graduate Research Element	Aerospace dynamics (lift, drag, resistance), calculating surface area of aircraft wing

Student Learning Goal:
Students will work in small groups to construct parachutes. They will discover how the surface area impacts the descent of a parachute. Students will construct two models to experiment with different sizes. For example, they might try a rectangular or triangular parachute. This gives students an insight to the design process. They will take their models outside and test them. They will notice the parachute sinks or decelerates downward. Different weights will be attached to the deceleration devices and the amount of weight the different sized parachutes can support will be recorded. The time of descent will also be recorded. Students will use the data to make inferences about the surface area and shape of the deceleration devices.

Materials Needed (supplies, hand-outs, resources):

- Plastic grocery-store bags with handles
- Paper
- string
- Glue
- Clear tape
- rulers

- Scissors
- Clay, Legos, weights, paper clips or object to attach to parachute for weight
- Graph paper & colored pencils OR computers with Microsoft Excel
- Stopwatch
- Scale

Lesson Performance Task/Assessment:
To build the parachute: Fold the plastic bag so that it is flat. Cut four strings out of the fishing line 12 inches long. Attach one end of each string to the parachute using the tape making sure the strings are spaced evenly around the edge of the shape. Attach the weight to the other four ends of the strings. Be careful not to tangle up the strings!! If clay is being used, it would be easy just to mold the clay around the strings. If paper clips are being used as the weights, make sure there is a loop in the knot to attach the paper clips in. If another object is being used for a weight, use tape to attach the object.

DAY 1: Constructing the parachutes
Give students a history of parachutes. Explain to students who uses them and why they are used. Introduce students to the appropriate terminology of a parachute: the plastic part is called the canopy and the strings are called the shroud. This may involve a Power Point presentation or perhaps a video.

Experiment with canopy shape: Students will measure and cut **two-three** different shapes such as square, rectangle, trapezoid, parallelogram, triangle, circle of the **same area** out of the plastic bags.

DAY 2: Go outside (weather permitting) to launch parachutes
Experiment with surface area: Students will measure and cut **two-three** different shapes such as square, rectangle, trapezoid, parallelogram, triangle, circle [BE SURE TO USE THE SAME SHAPES AS ABOVE) but of **different areas** out of the plastic bags.

Have students release their parachutes from the same height several times and observe the characteristics of the fall and measure and record the time. Calculate and record the average time for each shape and surface area. Also, if students experiment with various weights, be sure to have them record the weight and time of descent.

If possible, have students enter their data into a Microsoft Excel Spreadsheet and made a bar graph to show their results. If computers are not accessible, use graph paper and colored pencils to make graphs.

The instructor will bring the students back together to discuss the results. Have students comment on their conclusions about surface area and shape of the canopy and the impact they have on the descent time. Possible questions instruct can ask to invoke discussion:

- How much weight did your parachute hold?
- You might think of a parachute as flying machine, but it isn't. It is actually a deceleration device. What does deceleration mean? (It means to slow down.)
    - Why would we want a device to slow down? (safer landings, precious cargo)
- What would happen if we cut a small vent in the top of the parachute? (demonstrate in the classroom for students to see)

Lesson Relevance to Performance Task and Students:
Parachutes are used as emergency lifesaving devices, to transport and deploy supplies, equipment and people and to assist in slowing down an object for landing. Students will also get a taste of design optimization when they discover the best design for a parachute.

Anticipatory Set/Capture Interest:
Show students a real-world application of parachutes and how they have been used throughout history. NASA's Orion launch abort parachute system, NASA X-38, da Vinci's drawing, etc.

Guided Practice:
Teacher will give students a brief history of parachutes and required background knowledge on the math involved in surface area and the concept of air resistance. Teacher might show students several examples of parachutes that worked and ones that didn't to give them some ideas for their designs.

Independent Practice:
Students will work in small groups to design and construct their parachutes. Teacher will walk around the room and assist. If students are struggling with ideas, the teacher can demonstrate what happens when a crumpled up piece of paper is dropped versus a flat sheet of paper.

Remediation and/or Enrichment:
For enrichment, try experimenting with different length of shrouds to see if there is a relationship to canopy size. Students could also build a parafoil and observe the difference. They can visualize the difference between 2D and 3D objects. This lesson could also be developed further to include Newton's second law, F=ma, and students could learn about how this calculation could help them design a better parachute. It would also familiarize students with the concept of mass. The students could also experiment with various materials to make their canopies out of.

For remediation, only experiment with one variable, shape or surface area. This would shorten the lesson plan, as well. Individual IEPs will be supported.

Check(s) for Understanding:
Student should demonstrate an understanding of the engineering design process, invention and innovation, as well as testing and troubleshooting. Students understand if they can explain why their parachute was or was not successful and what the ideal parachute would be. They should be able to explain the concept of air resistance and describe a deceleration device. They should be able to explain the relationship between surface area and shape of the canopy and the impact on the performance of the parachute. The data should be organized and graphs should be evaluated for correctness.

Closure:
The instructor will bring the students back together to discuss the results. Have students comment on their conclusions about surface area and shape of the canopy and the impact they have on the descent time. Possible questions instruct can ask to invoke discussion:

- How much weight did your parachute hold?
- You might think of a parachute as flying machine, but it isn't. It is actually a deceleration device. What does deceleration mean? (It means to slow down.)
    - Why would we want a device to slow down? (safer landings, precious cargo)
- What would happen if we cut a small vent in the top of the parachute? (demonstrate in the classroom for students to see)
- Does material of the canopy matter?

Possible Alternate Subject Integrations:
Physics

Teacher Notes:
Don't let students put the plastic bags over their faces and make sure they are safe when releasing their parachute – don't let them climb ladders or stand on tables.

Recall important formulas for geometric shapes:
Area of circle = $\pi * r^2$, where r = radius
Area of square, rectangle, parallelogram = b*h, where b = base, h = height
Area of triangle = ½*b*h, where b = base, h = height
Area of trapezoid = ½*h*(a+b), where a and b are the parallel sides

Resources:
http://www.parachutehistory.com/eng/drs.html
http://en.wikipedia.org/wiki/NASA_X-38