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| **Fellow Name:** Lydia Smoot | **Contact Info:** [smootlg@mail.uc.edu](mailto:smootlg@mail.uc.edu)  [smoot.palerider@gmail.com](mailto:smoot.palerider@gmail.com) | **Date:** February 7, 2017 |
| **Teacher Name:** Mike Day | **School Name:** Reading High School | **Grade and Class:** Engineering  11th & 12th Grade |

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| **Activity Title:** | Save Barbie! |
| **Estimated Activity Duration:** | 50 minutes |

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| **Setting:** | **School gymnasium and bleachers** |

For this activity it is necessary to have flat surfaces and space to assemble the parachutes. It is also necessary to have a safe location to drop each Barbie & Parachute assembly for Testing. I will be utilizing the Reading High School Gymnasium for its large spaces where the teams can work and the high bleachers for drop testing the parachutes.

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| **Activity Objectives:** |

The students will be able to:

1. Identify Independent variables, dependent variables, and controls for the experiment
2. Formulate a hypothesis
3. Design, manufacture, and test 2 parachute designs
4. Track Fall-Time with stopwatch and record data
5. Describe Summarize results in worksheet
6. Compare their results with other teams
7. Draw conclusions about the properties of air resistance

**Goal:** Design and build a parachute that will slow Barbie’s fall (decrease her velocity) and allow her to land softly on the ground.

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| **Activity Guiding Questions:** |

1. What factors are we dealing with? Which ones are constant? Which ones can we change?
2. Based on what we know and have learned, can we predict the performance of the initial design?
3. What are the key features of the design? Why are they important?
4. What behavior was observed during testing?
5. Based on the data recorded, how effective was our design? Was the experiment successful?
6. How did other groups perform? How was our design different from others?
7. What affects fall time of an object? How is air resistance affected by our parachute? What changes improved Babies safety? What does this tell us about gravity, free fall, and air resistance?

**Main Idea:** Determine how surface area of parachute effects the air resistance and velocity of Barbie during her fall.

| **Next Generation Science Standards (NGSS)** | |
| --- | --- |
| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| * Asking questions (for science) and defining problems (for engineering) | * Patterns |
| ☐ Developing and using models | * Cause and effect |
| * Planning and carrying out investigations | * Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| * Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and  conservation |
| ☐ Constructing explanations (for science) and  designing solutions (for engineering) | * Structure and function. |
| * Engaging in argument from evidence | * Stability and change. |
| * Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
| --- |
| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| * Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| * Interpreting and Communicating Science Concepts **(C)** |
| * Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
| --- | --- |
| **Standards for Mathematical Practice (Check all that apply)** | |
| * Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| * Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of  others | * Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated  reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

* **HS. Forces and Interactions**: HS-PS2-1. Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

* **ONLS p330:** Physical Science - Forces, Momentum and Motion-
  + Newton’s laws applied to complex problems
  + Gravitational force and fields
  + Air resistance and drag
  + Forces in two dimensions

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

1 Activity Packet for each team

4 Trash Bags per team

1 Barbie per team

20 Pre-cut Strings per team

1 Scotch Tape per team

2 Masking Tape – shared item

1 Stop Watch – Timekeeper may use cell phone

1 Calculator per team

2 Measuring Tape – shared item

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| **Teacher Advance Preparation:** |

1. Before Activity Day
   1. Obtain Materials
   2. Cut String (20 per team, 80 total)
   3. Measure distance of drop area – 15ft ( m) from window to ground
   4. Create Activity Packet
2. On Activity Day
   1. Group desks – 4 rows of three
   2. Place group name tag on 1st desk in row
   3. Place bag of materials & 1 Packet 1st desk of row
   4. Cue Up – Intro Video

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| **Activity Procedures:** |

1. Teacher gives Pre-test a day before activity.
2. Students walk into classroom with desks moved around into groups of 3 for each team.
3. They find their name on the desk and sit with their group.
4. Video Clip begins after they are told to find seat. <https://www.youtube.com/watch?v=-EASqu5xyGU>
5. Start PowerPoint and discuss basic concepts surrounding air resistance.
6. Explain the mission to “Save Barbie.”
7. Have class follow along as you go through packet and discuss the goal of the lab.
8. Dismiss teams to begin 1st Design.

**(Steps 1- 8, 10 minutes)**

1. Teams assign rolls and work through packet which prompts them to check-in with teacher throughout the lab.
2. Each team sketches their initial parachute design & creates hypothesis
3. Record hypothesis in worksheet and calculate surface area
4. Each team builds initial design and attaches Barbie

**(Steps 9-12, 10 minutes)**

1. Arial Deployment Specialists throw Barbie from classroom windows 3 times, and Time Keepers record time while Technical Writer writes down all data.

(**Step 13, 5 minutes)**

1. Change in distance over time is calculated for each drop.
2. Each team returns to classroom to create final design.
3. New hypothesis is developed and written down, then surface area is recalculated   
   **(Steps 14-16, 10 min)**
4. Arial Deployment Specialists throw Barbie from classroom windows 3 times, and Time Keepers record time while Technical Writer writes down all data.

**(Step 17, 5 minutes)**

1. Change in Distance over time is calculated for each trial drop.
2. Teams returns to classroom and answers concluding questions in packet together, then takes Post-Test.

**(Step 18-19, 10 minutes)**

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

During this activity I will be **observing** each team as they construct their designs.

I will ask them **questions** to understand why they choose a certain size or shape or configuration.

Each team will state in their packet **why they made certain modifications** to their design. They will **draw conclusions** about their designs performance and determine if it was successful. Each team will watch the test drops of all the other teams and then **discuss** their results at the end of the Activity.

Each team worked out of the worksheet below during the activity and used it to track their designs and data. The rubric below was developed to assess their progress and attention to detail during the activity.

**Engineering Worksheet Grading Rubric – 35 Points Total**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Task** | **0 Points** | **1 Point** | **2 Points** | **3 Points** | **4 Points** |
| **Team Roles** | Team did not assign roles. | Teams assigned roles. |  |  |  |
| **Design Sketch (Qty 2)** | Team did not sketch. | Sketches complete but they lack units and dimensions. | Both Sketches complete with units of dimensions in picture. |  |  |
| **Surface Area  (Qty 2)** | No attempt was made to calculate. | Did not complete full calculation. | Full calculation but math error or incorrect use of equation. | Correct calculation but NO units. | Correct calculation with correct units. |
| **Hypothesizes  (Qty 2)** | No hypothesis recorded. | One hypothesis was created but it is not a complete thought. | Hypothesis 1 and 2 are complete and well thought out. |  |  |
| **Drop Time Table (Qty 2)** | Tables are not filled out. | Tables only partially filled out. | Tables Completely filled out |  |  |
| **Velocity Calculations (Qty 2)** | No attempt was made to calculate. | Did not complete full calculation. | Full calculation but math error or incorrect use of equation. | Correct calculation but NO units and NO circled velocity. | Correct calculation with correct units and circled velocity. |
| **Observations of Drop Tests  (Qty 2)** | Team did not write down observations of drop test. | Team did not describe the motion of Barbie and the parachute. | Team described the drop test and the motion of Barbie. |  |  |
| **Conclusion Questions** | Team did not complete the questions. | Team partially completed the questions. | Team completed all questions with well thought out responses. |  |  |

***Save Barbie!*** Engineering Worksheet



**Team Roles**

Time Keeper \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Technical Writer \_\_\_\_\_\_\_\_\_\_\_\_\_\_

Arial Deployment Specialist \_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Barbie’s Parachute**—Drawing Designs: *Please Include Dimensions*

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| --- |
| **Design 1 - Sketch** |
|  |

**Calculate Surface Area of Design 1 Below**—*Please Include proper Units*

**Hypothesis 1:** What do you think will happen during the Drop Test? Will Barbie be saved? Why do you think your design will/will not work?

**Barbie’s Parachute—**

|  |  |  |  |
| --- | --- | --- | --- |
| **DESIGN 1** | **Time (in seconds)** | | |
| **Surface Area (ft^2)** | **Drop 1** | **Drop 2** | **Drop 3** |
|  |  |  |  |

**Veloctiy Calculation-** Please calculate the velocities for drops 1, 2, and 3. Then circle the slowest velocity.

\_\_\_\_\_\_\_\_\_\_

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**Briefly Describe** - the motion of Barbie’s fall during the Drop test.

|  |
| --- |
| **Design 1 - Sketch** |
|  |

**Calculate Surface Area of Design 1 Below**—*Please Include proper Units*

**Hypothesis 2:** How do you think these changes will Save Barbie? Describe what happens to air resistance and the time of her fall.

|  |  |  |  |
| --- | --- | --- | --- |
| **DESIGN 2** | **Time (in seconds)** | | |
| **Surface Area (cm^2)** | **Drop 1** | **Drop 2** | **Drop 3** |
|  |  |  |  |

**Veloctiy Calculation-** Please calculate the velocities for drops 1, 2, and 3. Then circle the slowest velocity.

\_\_\_\_\_\_\_\_\_\_

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**Briefly Describe** - The motion of Barbie’s fall during the Drop test.

**Conclusion Questions –** Take time to reflect as a team on this experiment and answer the following questions together.

1. What did your team change from the initial design to the final design? Why?
2. Was your hypothesis correct? Explain.
3. What design yielded the slowest velocity?
4. What factors may have contributed to success of the parachute?
5. How do you think Surface Area and Velocity of Barbie’s fall are related?
6. If you had to do improve this activity, what would you do?

**Surface Area Shapes & Equations**

Remember – Surface Area is measured in



**Helpful Conversions**

12 inches = 1ft

30.48 cm = 1ft

2.54 cm = 1 inch

1 ft/s = 30.48 cm/s

12 in/s = 1 ft/s

**Summative Assessments:** Prepare a Pre-Test and Post-Test with the input of the RET Teacher. This should be a simple 10-12 question assessment tool. These questions will cover the content related to the Standards. The Pre and Post Test will be identical. There may be several summative assessments at the end of this Activity. Besides the Pre and Post Tests, the students might create a product for which this is a rubric developed. The rubric is also a summative assessment tool. Link the assessment tools.

Below are the Pre and Post Test given to the students. The items in green indicate the correct answer to the question and an explanation for each question is given below. The images below were not included on the Pre and Post Test but are there for explanation help only.

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_**

***Save Barbie!* RHS Engineering Activity**

Pre-Test

**Directions:** Circle the ***best*** possible answer for each question from the options given below.

1. **When does gravity affect objects?**
   1. **When they are on Earth**
   2. **Only when they are falling**
   3. **All the time, on Earth and in space**
   4. **Only in outer space**

*Explanation*: Gravity is a force that attracts all objects towards each other. The Moon and the Earth are attracted towards each other – this is why the oceans’ tides rise and fall. The Earth and Sun are attracted to each other – this is why the Earth orbits the Sun.

1. **Why do astronauts appear weightless in space?** 
   1. **There is no gravity in space**
   2. **They are moving very slowly**
   3. **There is no floor in space**
   4. **Their mass has decreased**

*Explanation:* Astronauts appear to be weightless for the same reason that a person on a trampoline feels weightless when in the air. There is still the same amount of gravity acting, but there is no floor pushing upwards on the astronaut, so the weight force cannot be felt.

1. **What type of friction is air resistance?**
   1. **static friction**
   2. **fluid friction**
   3. **rolling friction**
   4. **sliding friction**

*Explanation:* Air resistance is fluid friction. Air resistance occurs between the surface of a falling object and the air that surrounds it. Rolling friction occurs when a rounded surface moves over a solid and sliding friction occurs when a solid moves over another solid. Static friction occurs when a solid touches another solid but there is no movement.

1. **What two factors affect air resistance on an object?**
   1. **size and shape of the object**
   2. **weight of the object and distance from ground**
   3. **mass and size of the object**
   4. **all of these**

*Explanation:* Size and shape are the two factors that affect air resistance. Air resistance works with surface area, so the more surface area, the more air resistance. Think about when you drop two pieces of paper: one crumpled and one flat. The crumpled one falls faster because there is less air resistance acting on the paper

1. **In what direction does air resistance act on an object that is falling straight down?**
   1. **Right**
   2. **Down**
   3. **Up**
   4. **Left**

*Explanation:* Air resistance pushes up while gravity attracts an object downwards. This is true for objects falling straight down. If the object was falling left or right, then air resistance would be opposite. If both gravity and air resistance pulled down, then air resistance wouldn't be air resistance! Air resistance is the opposite of gravity for an object falling down.

1. **Scientifically speaking, what is a vacuum?**
   1. **when the mass is larger than the weight**
   2. **where there is no gravity**
   3. **where all of the air is removed**
   4. **when air is sucked into a small space**

*Explanation:* A vacuum is created when there is no air resistance (specifically, no air). A great example of a vacuum is space. If there was no air resistance in the world, every object would accelerate to the earth at 9.8 m/s/s, regardless of size and shape. A vacuum can also be created in a laboratory by taking a tube and sucking all of the air out of it, then dropping two objects inside. They drop at the same rate.

1. **What does it mean when an object is in free fall?**
   1. **no forces are acting upon the object**
   2. **all forces are acting on the object**
   3. **gravity is the only force acting upon the object**
   4. **air resistance is the only force acting upon the object**

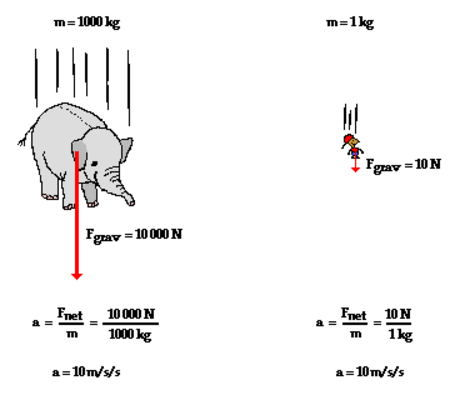
*Explanation:* When an object has no forces acting upon it other than gravity, the object is in free fall. The only time this would happen is if the object would be in a vacuum (i.e space). All objects would accelerate at the same rate, which is 9.8 m/s/s.

1. **A marble and a banana are dropped at the same time from the roof of Reading High School. Which object will fall slower is we neglect air resistance?**
   1. **Banana**
   2. **Marble**
   3. **Both**
   4. **None of the above**

*Explanation:* You could also have used a marble and a piano and a banana, or any two objects for which air resistance won’t be a big factor. The idea is that everything falls at the same rate, no matter what its mass is. A more massive object has more stuff for gravity to act on. But because it is more massive, it is also that much harder to move! A smaller object is easier to move. But it also has less stuff for gravity to act on! The cool thing is these two factors exactly balance each other out. And that’s why any object, from dump trucks to linguini, falls at exactly the same rate as any other object.

1. **A baby elephant and a fat mouse were dropped at the same time and are now in free fall. Which one will land first?**
   1. **Elephant**
   2. **Mouse**
   3. **Both**
   4. **None of the above**

*Explanation:* Free fall is a special type of motion in which the only force acting upon an object is gravity. Objects that are said to be undergoing free fall, are not encountering a significant force of air resistance; they are falling under the sole influence of gravity. Under such conditions, all objects will fall with the same rate of acceleration, regardless of their mass. *Image Part of Explanation*.



1. **A baby elephant and a fat mouse are dropped from the roof of Reading High School in the middle of a crosswind. Considering air resistance, which one will land first?**
   1. **Elephant**
   2. **Mouse**
   3. **Both**
   4. **None of the above**

*Explanation:* It can be said that the two most common factors that have a direct effect upon the amount of air resistance are the speed of the object and the cross-sectional area of the object. Increased speeds result in an increased amount of air resistance. Increased cross-sectional areas result in an increased amount of air resistance. A falling object will continue to accelerate to higher speeds until they encounter an amount of air resistance that is equal to their weight. Since the baby elephant weighs more (experiences a greater force of gravity), it will accelerate to higher speeds before reaching a terminal velocity. Thus, more massive objects fall faster than less massive objects because they are acted upon by a larger force of gravity; for this reason, they accelerate to higher speeds until the air resistance force equals the gravity force.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners. Refer to Activity Template for details. |

Half of the class is very analytical and the other have is very experiential. I tried to accommodate learning styles by creating an activity that would engage all the students simultaneously. I had the groups assign themselves tasks as the technical writer, timer, and Barbie dropper. The students would naturally pick something they were excited to do. The team followed their packet and used it to track their designs and data. They drew each design with dimensions and calculated surface area of their parachute. Then they worked together to create a hypothesis about the performance of each parachute before testing. Next, each group would drop their Barbie and parachute assembly three times and time each fall. Then they calculated their three velocities used the change in distance over the change in time.

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| **Reflection:** Reflect upon the successes and shortcomings of the Activity. This is done after the Activity is implemented. |

When explaining the activity to the students I do not think the goal of the activity was specific enough. In the future I would measure Barbie’s fall without a parachute and then tell the student to slow that specific velocity with their design. Also, I would clarify the outcome of a safe landing. When I taught the lesson I asked the student to slow Barbie’s falling velocity and to have her land slowly and safely on the ground. If I were to teach this activity again I would specify what it means to have Barbie land safely. For example, does she land on her feet or back or head? Or, is she dragged across the ground? And, can she lightly bump the ground before coming to a stop? I would tell the students she must land on her feet or bum, and she cannot be dragged or jerked by the parachutes activity during her fall. I would use the example of a real human using a parachute and how they might not be safe during their fall if the parachute jerked them in a direction or the landing place them on their head with many bumps or sliding.

Due to misprint error the students took an old version of the Pre and Post Test. The only difference resided in question 1 and 6. The correct version is attached to this document and the incorrect version that the student received is shown below. The underlined responses seen below were corrected to newer versions where can be seen under the Summative Assessments section.

1. **When does gravity affect objects?**
   1. **When they are on Earth**
   2. **Only when they are falling**
   3. **Erday ~~I’m~~ Gravity Hustlin**
   4. **Only in outer space**
2. **Scientifically speaking, what is a vacuum?**
   1. **when the mass is larger than the weight**
   2. **where there is no gravity**
   3. **where all of the air is removed**
   4. **a household appliance**

The Pre and Post test scores might indicate that the students didn’t learn much from the activity, but I beg to differ. Out of the 12 students in the engineering class, only one student was in physics class and that student did not score the highest on the Pre Test and scored lower on the Post Test. This being said, many of the student were unfamiliar with physics terms and had misconceptions about physics topics in general. Looking back on it now I believe the students would have benefited from extra time on this activity. Maybe the post test scores would have improved if I took time to teach some of these concepts and then present them in the activity. I was trying to use the activity to introduce and teach new concepts. But even if the students learn something new they didn’t retain it long enough to show positive results on the Post test.

If I were to do it all again I would update the pre/post-test since it was flawed. Question 2 confused all the students and some of the response choices were misleading. In the future I would adjust the answers to be more complex and less simplistic in hopes of clarifying the concept in question.

Through the formative assessment of the Save Barbie Engineering Worksheet, two groups did significantly reduce the velocity of Barbie’s fall with their second design. The other two teams did not move as quickly through the activity and did not have time to test their second design or record a second set of data.

**Common Errors In the Save Barbie Worksheet:**

* Did not show work for their surface area calculations
* Incorrect units for surface area
* Multiplied distance and time instead of dividing them to find velocity
* Brief hypothesis and description of observations during drop test
* Slopping design drawing and lack and no dimensions given

**Pre and Post Test Results**

Despite the disappointing results from my teaching performance, the student gave me lots of positive feedback. After the activity I quickly asked them is there was anything they would change or didn’t like. They suggest allowing more time for the activity, providing more materials to build the parachute out of, they also recommended a higher dropping platform such as the school roof. The students also told me they had fun during the activity. They stated it was something new they have never down before and it challenged them to think about gravity, free fall, air resistance, velocity, and surface are in a new way. The student’s conclusions questions from the Save Barbie Engineering Worksheet were also very telling. Although the students seemed confused about the concepts on the Pre and Post test, they were dead on correct while answering the conclusion question. Every group answered the fifth question correct which asked, “5) How do you think Surface Area and Velocity of Barbie’s fall are related?” Each group stated that when Surface Area of the parachute increased the velocity of Barbie’s fall slowed down. They also stated this behavior was due to drag or air resistance created by the parachute which counteracted gravity pulling Barbie down to the ground. This interesting discovery leads me to believe the students know the physics concepts but they are unsure how to identify them when present with very formal physics terminology and are unsure about t what they know when they are alone. Being in a group gives them confidence to answer correctly instead of doubt themselves, and simple question on the conclusion page presents the topics in a casual way verses the trickier formal questions on the Pre and Post Test.

If I were to do this activity again I would spread it over a couple days. I would begin with teaching or introducing the physics concepts to the students. Then I would introduce the activity and challenge them to find the physics concepts within the experiment. I would include markers in the material list and I would find a better drop site for testing Barbie and her parachute. A higher dropping distance would yield more dramatic results and demonstrate the concept of air resistance more effectively.