Learning Objectives

Learn about the Scientific Method and how to apply it to solve a problem. Learn about basic Statistics.

Materials and Preparation

Materials: Milk chocolate and Dark chocolate bars (we recommend Creamy Milk and 85% Cocoa by Lindt, but you can have different brands, as long as they have both the same dimensions). Sheet of paper, tape, and about 40 pennies, paper clips, rulers, craft sticks.

Introduction (20 minutes)

- What the video or ask the students to watch before class (-15min in class).
- Tell student the Scientific Method is a great way to test ideas about how things work.
- It follows a very specific and efficient formula to answer questions:
    o What is the problem?
    o Hypothesis: What is the possible answer?
    o Testing with an experiment.
    o Collecting data and analyzing it.
    o Draw a conclusion.
    o Repeat from Hypothesis, or not.
- Ask volunteers to share examples of when to use the scientific method.
- Tell them that engineers use this method often to solve problems and design great technologies. Today we'll do the same with chocolates.

Explicit Instruction/Teacher modeling (10 minutes)

- Let's start defining the problem. We have two chocolate bars, one is dark, the other is milk chocolate. If you look closely, as the video says, the dark chocolate has more cocoa powder and less butter than the milk chocolate.
- Ask them: Which chocolate is stronger?
- After having a pool, you as your class. Can my hypothesis be: "The Dark Chocolate is stronger"?
- The answer is **no**. This is a guess, not a hypothesis. A hypothesis must attempt to explain the problem and use previous knowledge for that.
- A hypothesis would be: "Because the dark chocolate has more cocoa, and cocoa is harder than butter, dark chocolates are stronger."
- But there is a catch: ask this question to the student: What is 'stronger'?
- Explain there are different kinds of strength: For example: Impact strength is different than compression strength. We have to pick one, and this depends on the way the material is used.

- Say that today we will measure Impact strength, because is more fun as it can teach us more how Captain America's shield work. So, which chocolate is stronger to an impact?

Guided Practice (5 minutes)

- Tell students they will be performing the experiment exactly how is shown in the video.
- Ask them to gather into groups of 3.
- Give to the students the Experimental Guide Sheet (attached) and go over the instructions with them.
- Explain that in Engineering, there are 'standards' and those are used to assure all data is comparable. So, we need to assure all class will do the same and we can do proper statistics – in simple words, to know if the collection of data actually makes sense and is trustworthy. Instead of relying on the results of one group, we will compare all to make a conclusion. We gather all data and take median value. The median is the average value. Things that may cause deviation from that: how precise the experiment is, how controlled the sample is, how many times we did it, etc.
- Tell the students: So let's find out which chocolate is stronger and if our hypothesis is correct. But let's do this with proper statistics!

Independent working time (35 minutes)

- Students should put together the device as instructed in the Experimental Guide Worksheet #1. Instruct them to record the results of the experiments in the Worksheet #2.
- Encourage the students to take a couple of minutes to assign tasks to individuals in the group.
- Give each group 20 minutes to create their testing machine with the provided materials. Once they've finished, let them test it with the chocolates provided and start recording the numbers of pennies needed to break each.
- Go over Worksheet #3, Analysis of the Results, with the students.
- Write on the board the results of the number of pennies needed to break each of the chocolates from each of the groups. Together with the students, calculate the median and the standard deviation.

Assessment (5 minutes)

- Construction of the setup
- Success of the construction
- Group work
- Group Discussion
- Median and deviation calculation

Closing and Review (5 minutes)

- Ask your students to reflect with their group on the following questions: Were you successful in this challenge? Why or why not? What was the most difficult part of this challenge? Why? If you were to do this again, what would you change?

ENGINEERING SUPERHEROES – Lesson #1

Worksheet #1 – 5th/6th grades

Create a device to compare which chocolate is the strongest.

Team Name:

_____

Group Members:

_____

_____

_____

ENGINEERING SUPERHEROES – Lesson #1

Worksheet #1 – 5th/6th grades

Experimental Guide Sheet

Materials: 2-3 bars of Milk chocolate and Dark chocolate (we recommend Creamy Milk and 85% Cocoa by Lindt), Sheet of paper, paper clip, ruler, tape, and about 40 pennies. You'll also need a wall, or a hard flat vertical surface.

Procedure: Take 10 pennies and wrap them with the paper sheet, then use the tape to create a paper tube, not too tight as you'll need to add more pennies later. Seal one of the sides with tape and fold the paper on the other side and place a paperclip so the coins won't fall out. Use the string and tie a knot around the pennies. Take a 12 inch long string and tape it to a wall or a hard flat stable surface (like a heavy box). This will create "battering ram". Lift the ram keeping the string straight and let it go. Mark on the wall where the ram hits it with a pencil.
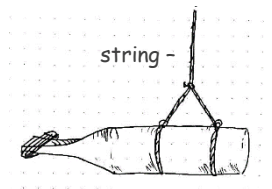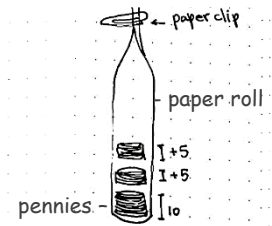
Take the paper of both chocolates and fold them till they become two hard thick rolls, or like a triangular shape (Figure A). If you are not using Lindt chocolates, you can cardboard to fold in a similar way. Tape them to the wall in between the ram hit-mark about 2 inches apart (Figure B), keeping a distance between them no greater than four blocks of your chocolate (if you chocolate has small blocks, make sure you have about 4 inches of chocolate in total).
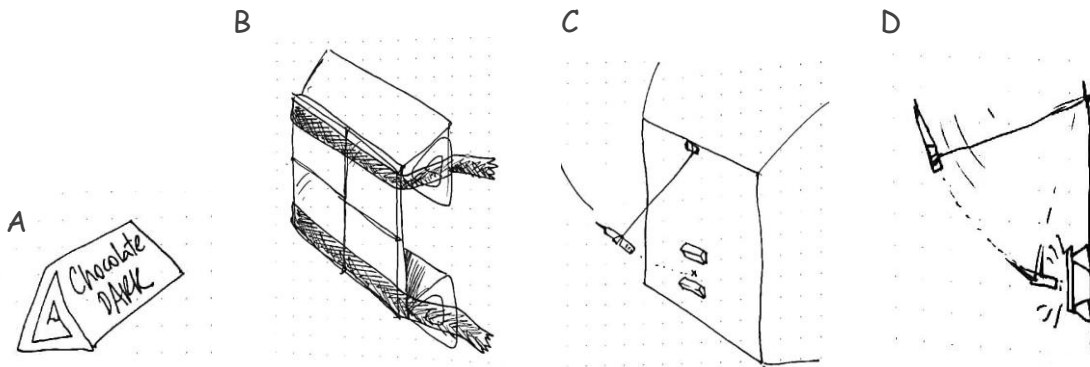
Then, tape the chocolate squares of your milk chocolate to the rolls (see Figure C), leaving an empty area behind the chocolate (see side view in Figure D). It is now time for the fun! Straighten the string and use a ruler to have it at 12in. Aim for the chocolate and let it go. You will notice that the chocolate may or may not break.

Increase the pennies by 5 to the battering ram paper tube, and try again until it breaks. Take notes using the Results Sheet.

Repeat then for the dark chocolate, starting again with only 10 pennies (remove all the additional pennies).

ENGINEERING SUPERHEROES – Lesson #1

Worksheet #2 – 5th/6th grades

Results Sheet

Fill out the table with the results of the impact test. If the bar breaks, mark the table with a **Y**, otherwise, with **N**.

If you have time and enough 'unbroken' chocolates, you can repeat the experiment as many times as your teacher allows.

Chocolate Type	Number of Pennies										
	10	15									
DARK	Y / N	Y / N									
MILK	Y / N										

Total number of Pennies needed to break:

Dark Chocolate Bar: _____

Milk Chocolate Bar: _____

ENGINEERING SUPERHEROES – Lesson #1

Worksheet #3 – 5th/6th grades

Analysis of the Results. Record in the table the number of pennies each group observed the chocolate bars to break. If there are more groups, add an additional table underneath.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Dark						
Milk						

Calculate the mean number of pennies needed to break each bar. Mean is the **sum** divided by the **count**. For example, if there were three groups, and they broke the Milk chocolate bar at 10, 15 and 10, the mean will be (10+15+10)/3.

	Mean Number of Pennies	Standard Deviation
Dark		
Milk		

Calculate the **Standard Deviation**. For each number: subtract the Mean and square the result. Then work out the mean of those squared differences. Take the square root of that and we are done. Put the result in the table above. The equation representing standard deviation is this:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

ENGINEERING SUPERHEROES – Lesson #1

Worksheet #3 – 5th/6th grades

Find the mean value and the standard deviation of each set of data. Round your answer to the two decimal places if needed.

Example: 23, 15, 15, 7

Data	Mean	Difference	Squared Difference
23	15	8	64
15	15	0	0
15	15	0	0
7	15	-8	64
Mean of Squared Difference			32
Standard Deviation			5.66

Problem: 78, 45, 60, 33, 84

Data	Mean	Difference	Squared Difference
Mean of Squared Difference			
Standard Deviation			