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STEM at Stead: Bouncy Balls

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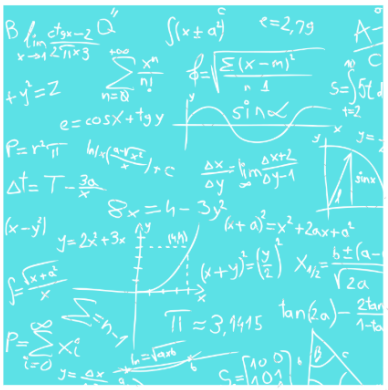
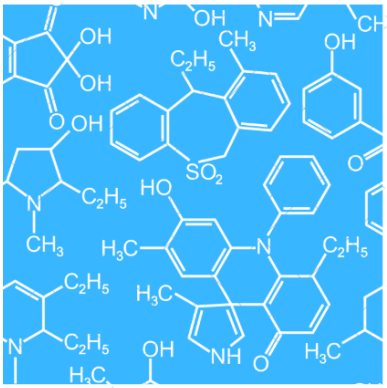
Bouncy Ball: Beginner Scientist



STEM at Stead



SCIENCE WORTH EXPLORING

Written by Aubree Larson

Bouncy Ball Teacher Information: Beginner Scientist

How do I prepare?

1. Double check that all the necessary supplies are inside of the kit:

   - table spoon sized measuring cup
   - 5 table spoons of borax
   - 5 tablespoons of corn starch
   - paper towels
   - 2 plastic cups
   - 5 tablespoons of school glue
   - food coloring
   - measuring tape
   - stirring sticks (these can be popsicle sticks or something similar))
   - latex gloves (or any material to keep food coloring off hands)

2. When the student begins this experiment, they will need to ask you to provide a half cup of warm water in the mixing bowl (plastic cup).
3. When the ball has been formed by the student, step 7, they will run through a few trials. After this, the ball will be placed in the freezer (or in a cup of ice) for 5 minutes and then another set of trials will be run. If the ball is placed in a cup of ice it needs to be in a plastic baggie. If the ball gets wet it won't be able to bounce.
4. Consider having the students fill out page 2 while the ball is in the freezer. This will help the time pass and provide an activity for this down time.

What will they learn?

1. The discussion materials for this experiment will be based off the Iowa Core Standards for third and fourth graders. The student does not have to be a third or fourth grader to complete this activity, they just need to be able to understand at a third-grade level. The standards covered by this experiment are:
   a. Physical Science → Motion and Stability: Forces and Interactions
      3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
   b. Engineering, Technology, and Applications of Science → Engineering Design
      3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
   c. Mathematics → Operations and Algebraic Thinking
      3.OA.D.8: Solve two–step word problems using the four operations. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

Need extra help?

If you aren't familiar with topics covered or if the student needs extra help, consider these resources:

www.billnye.com/the-science-guy/energy https://www.ducksters.com/science/physics/potential_energy.php

Bouncy Ball Instructions: Beginner Scientist

What is the experiment?

In this experiment you will be making your very own bouncy ball. The only materials you will need are corn starch, borax, glue, and water! Can you believe that? In order to stay safe during this experiment you have to wear latex gloves and protective eye wear. Both of these materials are provided in your kit.

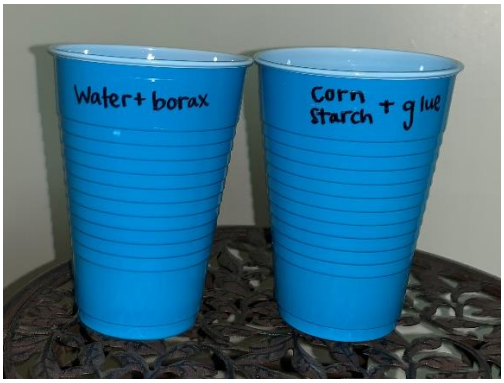
In this experiment you will be testing what temperature the bouncy ball should be at in order to bounce the highest. You will test one bouncy ball at room temperature and then you will test that same bouncy ball after it has been in a cold place for 5 minutes. You will drop the ball from a variety of different heights to see if a pattern develops!

Predict what you think will happen in this experiment. For example, how high will the bouncy ball go? Will the temperature of the bouncy ball affect the height it bounces?

Draw a picture for what you think will happen when you drop the bouncy ball from three different heights:

12 inches	**36 inches**	**60 inches**

Bouncy Ball Instructions: Beginner Scientist



Materials Needed:

table spoon sized measuring cup	2 cups for mixing
borax	school glue
corn starch	food coloring
paper towels	stirring sticks
gloves & goggles	yard stick

Instructions:

1. You should have two mixing cups in your kit. Label one "water + borax" and the other "corn starch + glue"
2. Ask the teacher in your room to put half a cup of warm water into the "water + borax" cup.
3. Measure out ½ a table spoon of borax and dump it into the water. Use one of the stirring sticks to dissolve the borax in the water. It is okay if there is still some left at the bottom.
4. Measure out ½ a table spoon of corn starch and place it in the "corn starch + glue" cup. Measure out ½ a table spoon of school glue and place it in the cup that has the corn starch at the bottom. Use the other stirring stick to mix the ingredients in the "corn starch + glue" cup together.
5. Choose 1 color from the food coloring and put 3 drops into the "corn starch + glue" cup. Mix the food coloring in until the mixture looks like the top picture on the left.
6. Now dump the mixture from the "water + borax" cup into the "corn starch + glue" cup. Mix until the glue mixture becomes hard. Hard enough that you can no longer stir.
7. Put on the gloves. Take the glue mixture out of the cup and roll it in your hands to form a ball. Make sure to work the ball in your hands so there are no glue pockets. Freeze the ball for 5 minutes.
8. You're ready to start bouncing your ball! Follow the instructions under section A on the next page and fill out the table as you complete your trials.
9. After you have completed section A, fill out section B.
10. Now you will test the bouncy ball when it is cold. Ask the teacher to place the bouncy ball in the freezer for 5 minutes. After the 5 minutes is up, complete another 9 trials in part C of the discussion section. Reflect on the trials section D.
11. Read through the information on page 6 and reflect on your prediction in part E. Turn the finished materials into your teacher.

Bouncy Ball Discussion Materials: Beginner Scientist

A. Document the results of your trials below:

There are specific heights you should drop (drop, not throw!) your bouncy ball from. Each time you drop the ball, watch how high it bounces back up. Perform three trials for each height. This means you will drop the ball a total of 9 times.

Height ball is dropped from	Trial	Height ball bounces back up (in inches)
12 inches	1	
	2	
	3	
36 inches	1	
	2	
	3	
60 inches	1	
	2	
	3	

B. If I wanted a bouncy ball to bounce back up at least 20 inches, what height should I drop the ball from? What if I wanted the ball to bounce back up 40 inches?

Bouncy Ball Discussion Materials: Beginner Scientist

C. Document the results of your trial below

D. There are specific heights you should drop (drop, not throw!) your bouncy ball from. Each time you drop the ball, watch how high it bounces back up. Perform three trials for each height. This means you will drop the ball a total of 9 times.

Height ball is dropped from	Trial	Height ball bounces back up (in inches)
12 inches	1	
	2	
	3	
36 inches	1	
	2	
	3	
60 inches	1	
	2	
	3	

E. If I wanted a bouncy ball to bounce back up at least 20 inches, what height should I drop the ball from? What if I wanted the ball to bounce back up 40 inches?

Bouncy Ball Discussion Materials: Beginner Scientist

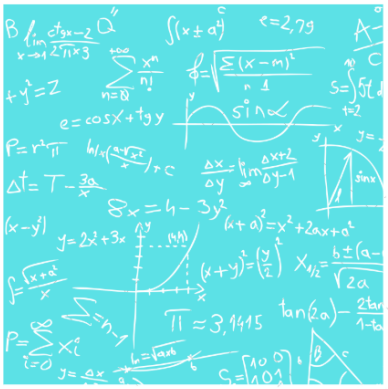
The science behind bouncy balls

Energy and forces can explain why the ball bounced back up when you dropped it to the floor. First, let's talk about energy. There are two forms of energy: potential and kinetic. Potential energy is known as stored energy. An object has potential energy because of its position. An example is a bike at the top of a hill or a book up on a shelf. Kinetic energy is known as the energy of motion. Potential energy is converted to kinetic energy when the object starts to move. Holding the ball in your hand, it was storing potential energy. As soon as you released the ball from your hand, this energy was converted to kinetic energy. This conversion happens a second time during the ball bouncing. There is a very small moment when the ball is still on the ground. After this moment, the ball reverses its direction and bounces back up towards your hand. When the ball was still on the ground it was storing potential energy. When the ball reversed its direction, the energy was converted from potential to kinetic. But what science explains why the ball reversed direction?

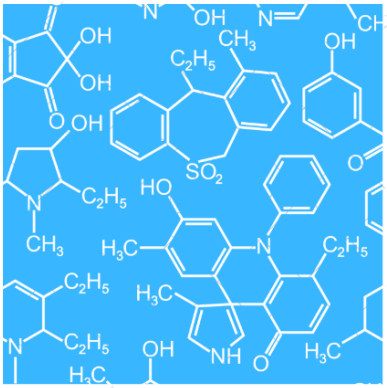
Forces! The ball was brought to the ground by the force of gravity and the ball went back into the air because the ground provided an equal force to that of gravity. Let's break that down. When the ball hits the ground there is a balanced force pair that happens. The ground provides an equal force to that of gravity, which changes the direction of the ball's movement. The ball slows down while it is bouncing back up because once again gravity forces it back down to the earth's surface. So there you have it! Forces and energy are what puts the bounce in bouncy balls!

F. Do your results align with your prediction? Why do you think this is?

Bouncy Ball: Practiced Scientist



STEM at Stead



SCIENCE WORTH EXPLORING

Written by Aubree Larson

Bouncy Ball Teacher Information: Practiced Scientist

How do I prepare?

5. Double check that all the necessary supplies are inside of the kit:

   - table spoon sized measuring cup
   - 5 tablespoons of borax
   - 5 tablespoons of corn starch
   - paper towels
   - goggles
   - measuring spoons
   - stirring sticks (these can be popsicle sticks or something similar)
   - 2 plastic cups
   - 5 tablespoons of school glue
   - food coloring
   - measuring tape
   - latex gloves

6. When the student reaches a certain step in this experiment, they will need to ask you to provide a half cup of warm water in the mixing bowl. You will need to do this twice during the course of the experiment.
7. When the ball has been formed by the student, step 7, they will run through a few trials. After this, the ball will be placed in the freezer (or in a cup of ice) for 5 minutes and then another set of trials will be run. If you place it in a cup of ice, it needs to be in a Ziploc baggie. If the ball gets wet, it will not bounce.
8. Consider having the students fill out page 2 while they are waiting the 5 minutes their ball to freeze.

What will they learn?

2. The discussion materials for this experiment will be based off the Iowa Core Standards for seventh graders. The student does not have to be a seventh grader to complete this activity, they just need to be able to understand at a seventh-grade level. The standards covered by this experiment are:
   d. Physical Science → Energy
      MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.
   e. Engineering, Technology, and Applications of Science → Engineering Design
      MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Need extra help?

If you aren't familiar with topics covered or if the student needs extra help, consider these resources:

www.billnye.com/the-science-guy/energy

www.billnye.com/the-science-guy/motion

https://www.ducksters.com/science/physics/potential_energy.php

https://www.ducksters.com/science/physics/kinetic_energy.php

Bouncy Ball Instructions: Practiced Scientist

What is the experiment?

In this experiment you will be making your very own bouncy ball. The only materials you will need are corn starch, borax, glue, and water! Can you believe that? In order to stay safe during this experiment you have to wear latex gloves and protective eye wear. Both of these materials are provided in your kit.

In this experiment you will be testing the mass the bouncy ball should be at in order to bounce the highest. You will test one bouncy ball at a baseline mass and then you will make another bouncy ball with double the amount of materials you used to create the first one. You will drop the ball from a variety of different heights to see if a pattern develops!

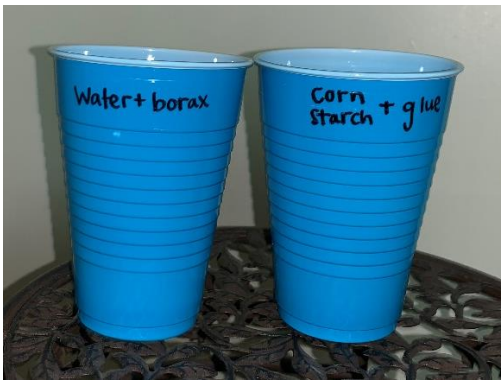
Predict what you think will happen in this experiment. For example, how high will the bouncy ball go? Will the mass of the bouncy ball affect the height it bounces?

Draw a picture of what you think will happen when you drop the two different bouncy balls:

Baseline mass

Double the mass

Bouncy Ball Instructions: Practiced Scientist



Materials Needed:

table spoon sized measuring cup	2 cups for mixing
borax	school glue
corn starch	food coloring
paper towels	stirring sticks
gloves & goggles	measuring tape

Instructions:

12. You should have two mixing cups in your kit. Label one "water + borax" and the other "corn starch + glue"
13. Ask the teacher in your room to put half a cup of warm water into the "water + borax" cup.
14. Measure out ½ a table spoon of borax and dump it into the "water + borax" cup. Use one of the stirring sticks to dissolve the borax in the water. It is okay if it is not completely dissolved.
15. Measure out ½ a table spoon of corn starch and place it in the "corn starch + glue" cup. Measure out ½ a table spoon of school glue and place it in the cup that has the corn starch at the bottom. Use the other stirring stick to mix these two ingredients together.
16. Choose 1 color from the food coloring and put 3 drops into the "corn starch + glue" cup. Mix the food coloring in until the mixture looks like the top picture.
17. Now dump the contents of the "water + borax" cup into the "corn starch + glue" cup. Mix until the glue mixture becomes hard. Hard enough that you can no longer stir.
18. Put on the gloves. Take the glue mixture out of the cup and roll it in your hands to form a ball. Make sure to work the ball in your hands so that there are no glue pockets. Place the ball on a cup of ice for 5 minutes or in the freezer.
19. You're ready to start bouncing your ball! Read part A on the next page and fill out a row in the table each time you bounce the ball. Then fill out part B before coming back to this page.
20. Now you will test the bouncy ball when it is double the size. Repeat steps 1-7 but double the amounts for all the ingredients (except for the food coloring). Record your trials in section C. Record your prediction in part D.
21. Graph the results from both sets of trials (A and C) on the graph paper provided on page 6.
22. After finishing graphing, read through the materials on page 7 and fill out part E and F.

Bouncy Ball Discussion Materials: Practiced Scientist

A. Document the results of your trials below: WARM WATER

There are specific heights you should drop (drop, not throw!) your bouncy ball from. Each time you drop the ball, watch how high it bounces back up. Perform three trials for each height. This means you will drop the ball a total of 9 times.

Height ball is dropped from	Trial	Height ball bounces back up (in inches)
12 inches	1	
	2	
	3	
36 inches	1	
	2	
	3	
60 inches	1	
	2	
	3	

B. If I wanted a bouncy ball to bounce back up at least 20 inches, what height should I drop the ball from? What if I wanted the ball to bounce back up 40 inches?

Bouncy Ball Discussion Materials: Practiced Scientist

C. Document the results of your trials below: COLD WATER

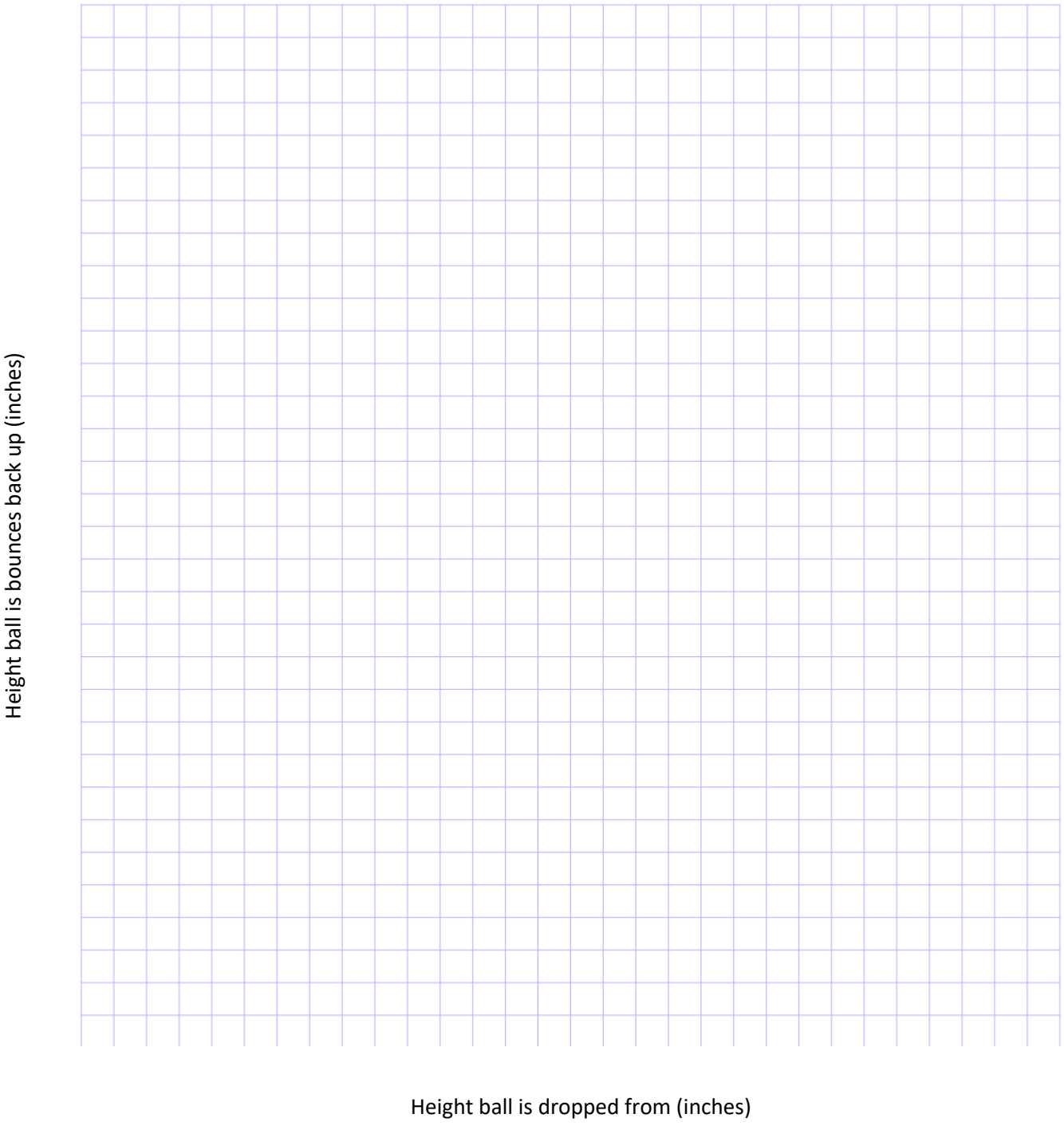
There are specific heights you should drop (drop, not throw!) your bouncy ball from. Each time you drop the ball, watch how high it bounces back up. Perform three trials for each height. This means you will drop the ball a total of 9 times.

Height ball is dropped from	Trial	Height ball bounces back up (in inches)
12 inches	1	
	2	
	3	
36 inches	1	
	2	
	3	
60 inches	1	
	2	
	3	

D. If I wanted a bouncy ball to bounce back up at least 20 inches, what height should I drop the ball from? What if I wanted the ball to bounce back up 40 inches?

Bouncy Ball Discussion Materials: Practiced Scientist

Use two different colors to graph your results. One color for your warm water trials (from section A) and one color for your cold water trials (from section C).



Bouncy Ball Discussion Materials: Practiced Scientist

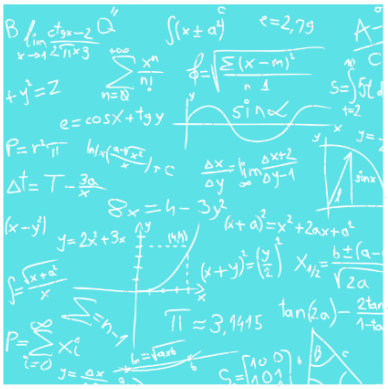
The science behind bouncy balls

Energy and forces can explain why the ball bounced back up when you dropped it to the floor. First, let's talk about energy. There are two forms of energy: potential and kinetic. Potential energy is known as stored energy. An object has potential energy because of its position. An example is a bike at the top of a hill or a book up on a shelf. Kinetic energy is known as the energy of motion. Potential energy is converted to kinetic energy when the object starts to move. Holding the ball in your hand, it was storing potential energy. As soon as you released the ball from your hand, this energy was converted to kinetic energy. This conversion happens a second time during the ball bouncing. There is a very small moment when the ball is still on the ground. After this moment, the ball reverses its direction and bounces back up towards your hand. When the ball was still on the ground it was storing potential energy. When the ball reversed its direction, the energy was converted from potential to kinetic.

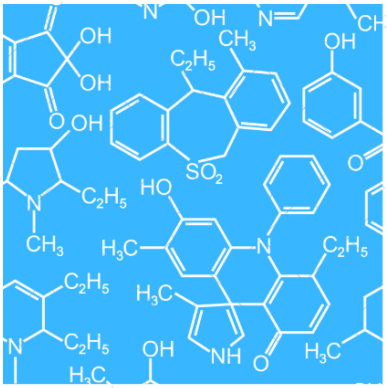
E. After graphing your result, what do you determine is the optimal weight for your bouncy ball to reach 6 feet when dropped?

F. Do your conclusions align with your prediction? Why or why not?

Bouncy Ball: Advanced Scientist



STEM at Stead



SCIENCE WORTH EXPLORING

Bouncy Ball Teacher Information: Advanced Scientist

How do I prepare?

9. Double check that all the necessary supplies are inside of the kit:

   - table spoon sized measuring cup
   - 5 tablespoons of borax
   - 5 table spoons of corn starch
   - paper towels
   - latex gloves
   - 2 plastic cups
   - 5 tablespoons of school glue
   - food coloring
   - measuring tape
   - goggles
   - stirring sticks (these can be popsicle sticks or something similar)

10. When the student starts, they will need to ask you to provide a half cup of warm water in one of the mixing cups. Later (step 10) the student will ask for cold water. Make sure the water is much. Much colder than the first half cup of water.
11. When the ball has been formed by the student, step 8, they will run through a few trials. After this, the first 9 steps will be run again. Once the student has made the bouncy ball with cold water, you will need to put it on ice or in the freezer for 5 minutes. You can also cover the ball in ice, but you need to put it in a Ziploc baggie. If the ball gets wet, it will be too sticky to bounce.
12. Consider having the students fill out the second page of the materials while they are waiting the five minutes for their ball to freeze.

What will they learn?

3. The discussion materials for this experiment will be based off the Iowa Core Standards for high school students. The student does not have to be a high schooler to complete this activity, they just need to be able to understand at a high school level. The standards covered by this experiment are:
   f. Algebra → Creating Equations
      HSA.CED.A.2: Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
   g. Physical Science → Matter and Its Interactions
      HS-PS1-5: Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Need extra help?

If you aren't familiar with topics covered or if the student needs extra help, consider these resources:

www.billnye.com/the-science-guy/energy www.billnye.com/the-science-guy/motion

https://www.scientificamerican.com/article/bring-science-home-playing-with-polymers/

Student Questions: Advanced Scientist

What is the experiment?

In this experiment you will be combining ingredients to create a product. When you are combining ingredients there will be a reaction that will occur. Remember to practice proper safety and wear protective eyewear and gloves throughout the experiment. There are four ingredients that you will need to perform this experiment: water, borax, corn starch, and glue.

Predict what product you think these ingredients will make when combined:

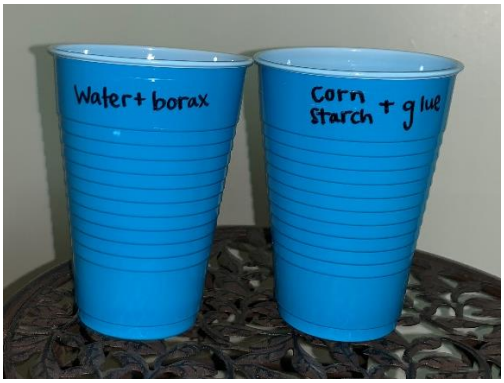
Believe it or not, these ingredients are going to create a bouncy ball! You are going to be testing the rate of reaction when making this bouncy ball. The first time you will use warm water when mixing the ingredients together. The next time you will use very cold water when mixing the ingredients together.

Predict how temperature of the water is going to affect the rate of reaction:

You will also be testing how high each of your two bouncy balls bounces. You will be testing them from varying heights to see if you can predict a pattern of the bouncy ball's motion.

Do you think temperature will affect the height the ball bounces? If so, which will bounce higher?

Bouncy Ball Instructions: Advanced Scientist



Materials Needed:

table spoon sized measuring cup	2 cups for mixing
borax	school glue
corn starch	food coloring
paper towels	stirring sticks
gloves & goggles	measuring tape

Instructions:

23. There should be four cups in your kit. Label one “water + borax” and the other “corn starch + glue”. Leave the other two blank for now.
24. Ask the teacher in your room to put half a cup of really warm water into the “water + borax” cup. Put on your goggles.
25. Measure out ½ a table spoon of borax and dump it into the water. Use one of the stirring sticks to somewhat dissolve the borax.
26. Measure out a ½ a table spoon of corn starch and place it in the “corn starch + glue” cup. Measure out ½ a table spoon of school glue and place it in the cup that has the corn starch at the bottom. Use the other stirring stick to mix these two ingredients together.
27. Choose 1 color from the food coloring and put 3 drops into the “corn starch + glue” cup. Mix the food coloring in until the mixture looks like the top picture.
28. Look at the clock, write down the time next to “first combined together” in the table under section A on the next page.
29. Now dump the water + borax into the cup with the glue. Mix until the glue mixture becomes hard enough that you can no longer stir.
30. Record the time you thought the mixture was sufficiently mixed next to “mixture sufficiently stirred” in the table under section A on the next page. Calculate how long it took the reaction to complete and fill in the rest of the table in section A.
31. Put on the gloves. Take the glue mixture out of the cup and roll it in your hands to form a ball. Make sure to roll it sufficiently so that there are no glue pockets left. You may need to freeze the ball to be able to get it to bounce. Run trials to fill in part B.
32. You will now make a new bouncy ball, but this time cold water will be used. Repeat steps 1-6 but ask your teacher for COLD water this round. And after you have rolled the ball, place it on ice for 5 minutes. Again, fill out the time it takes for the reaction to occur in part C and the height from your trials in part D.
33. Graph your results in part F and then create an equation for each line (one for cold and one for warm) in part G. Use those equations to solve the question in part H.
34. Finally, complete parts I and J on page 7.

Bouncy Ball Discussion Materials: Advanced Scientist

A. Document the results of your mixture below: WARM WATER

Phase of the Mixture	Time
First combined together	
Mixture sufficiently stirred	
Time it took for reaction to complete	

B. Document the results of your trials below: WARM WATER

There are specific heights you should drop (drop, not throw!) your bouncy ball from. Each time you drop the ball, watch how high it bounces back up. Perform three trials for each height. This means you will drop the ball a total of 9 times.

Height ball is dropped from	Trial	Height ball bounces back up (in inches)
12 inches	1	
	2	
	3	
36 inches	1	
	2	
	3	
60 inches	1	
	2	
	3	

C. Document the results of your mixture below: COLD WATER

Phase of the Mixture	**Time**
First combined together	
Mixture sufficiently stirred	
Time it took for reaction to complete	

D. Document the results of your trials below: COLD WATER

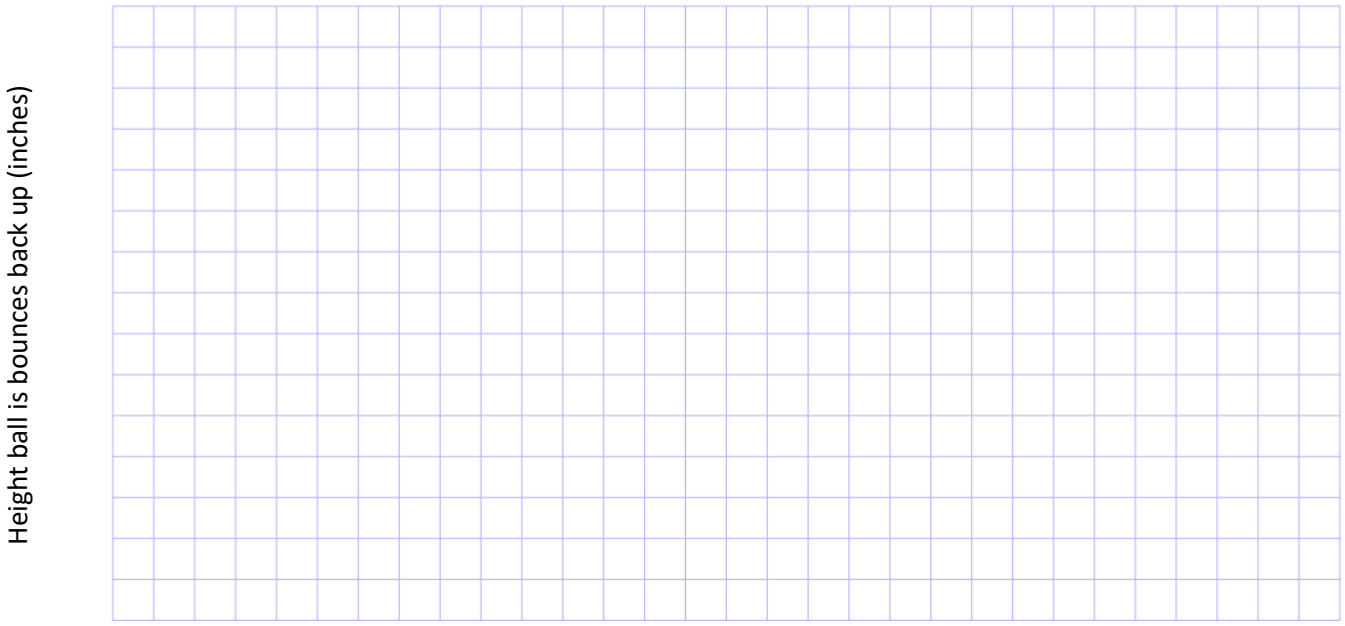
There are specific heights you should drop (drop, not throw!) your bouncy ball from. Each time you drop the ball, watch how high it bounces back up. Perform three trials for each height. This means you will drop the ball a total of 9 times.

Height ball is dropped from	Trial	Height ball bounces back up (in inches)
12 inches	1	
	2	
	3	
36 inches	1	
	2	
	3	
60 inches	1	
	2	
	3	

E. Did the cold or warm bouncy ball bounce higher? Why do you think this is?

Bouncy Ball Discussion Materials: Advanced Scientist

F. Use two different colors to graph your results. One color for your warm water trials (from section B) and one color for your cold water trials (from section D).



G. Write an equation for each of the lines:

Cold →

Warm →

H. If you dropped the cold ball from 49 inches, how far would it bounce back up? Use your equation to calculate?

The science behind bouncy balls

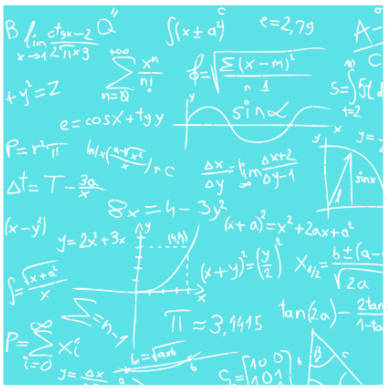
When all the mixtures were combined into one cup the borax reacted with the glue which caused long chains of molecules to stick together and form what we call elastomers. An elastomer is a polymer that has elastic properties and a polymer is what we call a long chain of molecules. Calling something an elastomer is a fancy way of saying that the substance can bounce. Not only does this mean that you can throw the bouncy ball of a wall and it will bounce off every surface it comes into contact with, but it can also be stretched ten times its normal size and it will return to its original shape without permanent deformation. But how is this possible?

Entropy. Entropy is a measure of disorder. By definition entropy measures the gradual decline towards disorder. It is the measure of the gradual decline towards disorder for everything in the universe because it is easier to maintain disorder rather than order. Think of it this way: it is much easier to keep your room messy than it is to keep your room clean. It is the same way for everything in our universe. An elastomer is a random combination of polymers winding and tangling around one another. When you stretch an elastomer, you are forcing the molecules to line up in the direction that it is being stretched. An elastomer prefers an increase in entropy so stretching it is not ideal. That is why when you let go the elastomer will return to its original shape. That is why a bouncy ball doesn't splatter against the ground, it stretches momentarily and then returns to its original shape.

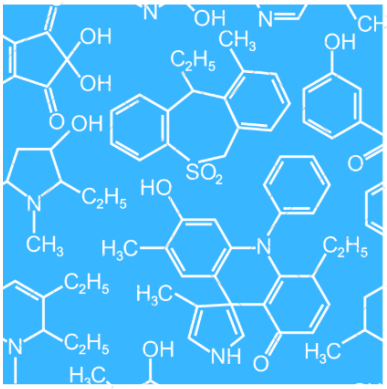
I. After analyzing your results, how did the temperature effect the rate of the mixture? Did this match your prediction?

J. Did temperature of the mixture/ ball affect the height it bounced? Did this match your prediction?

Bouncy Ball: Personal Power



STEM at Stead



SCIENCE WORTH EXPLORING

Written by Aubree Larson adapted by A. R. Butz from Promoting Mentee Research Self-Efficacy (Byars-Winston, Leveritt, Branchaw,& Pfund, 2013, 2016). University of Wisconsin-Madison. Supported by NIH grant # R01 GM094573 (ByarsWinston, PI). Branchaw, J. L., Butz, A. R., & Smith A. (2018). Entering Research (2nd ed.). New York: Macmillan.

Bouncy Ball Teacher Information: Personal Power

When do I give the student this work sheet?

This work sheet is meant to be completed after the entire experiment has been completed. This worksheet is best if the student performed the experiment without a partner. There is a separate work sheet for scientists who completed this experiment with a partner.

What will they learn?

4. The discussion materials for this experiment will be based off the Iowa Core Standards for Employability Skills. These standards are consistent across all age groups, so this work sheet can be used for any aged scientist. The following standards that will be reflected on through this work sheet are:
   h. 21.9 – 12.ES.2
      Adapt to various roles and responsibilities and work flexibly in climates of ambiguity and changing priorities.
      - Adapt to varied roles, responsibilities, and expectations
      - Work effectively in a climate of ambiguity and changing priorities
      - Demonstrate appropriate risk-taking
   i. 21.9 – 12.ES.4
      Demonstrate initiative and self-direction through high achievement and lifelong learning while exploring the ways individual talents and skills can be used for productive outcomes in personal and professional life.
      - Perform work without oversight
      - Use time efficiently to manage workload
      - Assess one's master of skills
      - Set and achieve high standards and goals
      - Engage in effective problem-solving process

Bouncy Ball Scientist Information: Personal Power

1. **Read through the following cognitive distortions:**

   Cognitive distortions are irrational thoughts that can influence your emotions. Everyone experiences cognitive distortions to some degree, but in their more extreme forms they can be harmful

   a. Magnification and Minimization: Exaggerating or minimizing the importance of events. One might believe their own achievements are unimportant, or that their mistakes are excessively important
      i. Catastrophizing: Seeking only the worst possible outcomes of a situation.
   b. Overgeneralization: Making broad interpretations from a single or few events. "I felt awkward during my job interview. I am *always* so awkward."
   c. Magical Thinking: The belief that acts will influence unrelated situations. "I am a good person – bad things shouldn't happen to me."
   d. Personalization: The belief that one is responsible for events outside of their own control. "My mom is always upset. She would be fine if I did more to help her."
   e. Jumping to Conclusions: Interpreting the meaning of a situation with little or no evidence.
      i. Mind Reading: Interpreting the thoughts and beliefs of others without adequate evidence. "She would not go on a date with me. She probably thinks I'm ugly."
      ii. Fortune Telling: The expectation that a situation will turn out badly without adequate evidence.
   f. Emotional Reasoning: The assumption that emotions reflect the way things really are. "I feel like a bad friend, therefore I must be a bad friend."
   g. Disqualifying the Positive: Recognizing only the negative aspects of a situation while ignoring the positive. One might receive many compliments on an evaluation, but focus on the single piece of negative feedback.
   h. "Should" Statements: The belief that things should be a certain way. "I should always be friendly."
   i. All-or-Nothing Thinking: Thinking in absolutes such as "always", "never", or "every". "I never do a good enough job on anything.

Bouncy Ball Scientist Information: Personal Power

2. **Identify the cognitive distortion (or multiple distortions) described during these paragraphs:**
    a. *Suzy is completing the bouncy ball experiment. She can't get her bouncy ball to bounce as high as she wants to. The ball splats every time she throws it on the ground. Suzy feels like she keeps failing at this task. Eventually, Suzy thinks to herself, "I can't get this bucket to stay on and it's making me feel stupid. If I feel stupid during this experiment, then I must be stupid all the time."*

    b. *Bob just finished the bouncy ball experiment. When he hands the materials in to his teacher, the teacher congratulates him. He got 19/20 right on his discussion materials. Bob is mad that he didn't get 20/20. He can't believe he missed a problem. Bob isn't happy with his performance at all, he is mad that he got something wrong.*

    c. *Walter is working through the bouncy ball experiment. He does not quite understand how to measure out the ingredients. He starts to worry that he won't be able to make any part of the bouncy ball and he won't finish any of the discussion materials. He imagines this means he is going to fail this experiment.*

Bouncy Ball Scientist Information: Personal Power

d. *Karen handed in her discussion materials to her teacher nearly 5 minutes ago. She can see the teacher writing things on her paper as they go through it. Karen immediately thinks that she did poorly on this experiment. The teacher would not be spending so much time on her paper if she had done well. However, when she gets her paper back she sees she did well. Her teacher wrote things like "good job" and "nice work" throughout her materials.*

3. Read through these four sources of self-efficacy:

Self-efficacy is a belief one has in his/ her ability to successfully complete a given goal or task. In other words, it is a situation-specific self-confidence. It answers the question "can I do this?" Self-efficacy is informed by four sources: mastery experience, vicarious experience, social persuasion, and emotional/ physiological state. Here are some examples:

1. Mastery experience: a past accomplishment or success: "I've done this before"
2. Vicarious experience: a model that has successfully completed the task: "I've seen others do this before"
3. Social persuasion: a social or verbal message reinforcing ability or effort: "Others have told me that I can do this"
4. Emotional/ physiological state: an emotional, affective, or physiological response: "Doing science in the classroom makes me happy," "I get excited when I am doing a science experiment," or "my heart starts racing when I begin to conduct an experiment."

4. Identify how Suzy, Bob, Walter, and Karen could use self-efficacy to help deal with their cognitive distortions:

Suzy: Bob: Walter: Karen:

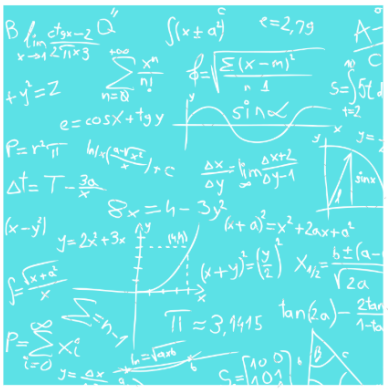
Bouncy Ball Scientist Information: Personal Power

5. Now practice dealing with your cognitive distortions while you work on through this exercise:

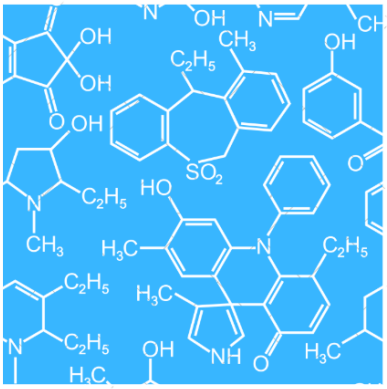
Think about an invention that could help you or society as a whole. The invention needs to use the same scientific principles as the bouncy ball you made earlier. Write down/ draw your ideas:

6. Explain how you improved your behavior this time when you worked towards this invention:

Bouncy Ball: Personal Power with Partners



STEM at Stead



SCIENCE WORTH EXPLORING

Written by Aubree Larson adapted from Brune (1993). Facilitation Skills for Quality Improvement. Quality Enhancement Strategies. 1008 Fish Hatchery Road. Madison WI 53715. Branchaw, J. L., Butz, A. R., & Smith A. (2018). Entering Research (2nd ed.). New York: Macmillan.

Bouncy Ball Teacher Information: Personal Power

When do I give the student this work sheet?

This work sheet is meant to be completed after the entire experiment has been completed. This work sheet is only relevant if the scientist worked with a partner or group to complete this experiment. There is a separate work sheet for scientists who completed this experiment alone.

What will they learn?

5. The discussion materials for this experiment will be based off the Iowa Core Standards for Employability Skills. These standards are consistent across all age groups, so this work sheet can be used for any aged scientist. The following standards that will be reflected on through this work sheet are:
   j. 21.9 – 12.ES.1
      Communicate and work productively with others, incorporation different perspectives and cross-cultural understanding, to increase innovation and the quality of work
      - Work appropriately and productively with others
      - Use different perspectives to increase innovation and the quality of work
      - Use all the appropriate principles of communication effectively
   k. 21.9 – 12.ES.3
      Demonstrate leadership skills, integrity, ethical behavior, and social responsibility while collaborating to achieve common goals
      - Use interpersonal skills to influence and guide others toward a goal
      - Leverage the strengths of others to accomplish a common goal
      - Demonstrate integrity and ethical behavior
      - Demonstrate mental, physical, and emotional preparedness to accomplish the task
   l. 21.9 – 12.ES.5
      Demonstrate productivity and accountability by meeting high expectations
      - Deliver quality job performance on time
      - Demonstrate accountability for individual performance

Bouncy Ball Scientist Information: Personal Power

7. **Read through the following constructive group behaviors and identify one behavior that you exhibited during the bouncy ball experiment:**
   Constructive Group Behaviors →
   a. Cooperating: Is interested in the views and perspectives of other group members and willing to adapt for the good of the group.
   b. Clarifying: Makes issues clear for the group by listening, summarizing, and focusing discussions.
   c. Inspiring: Enlivens the group, encourages participation and progress.
   d. Harmonizing: Encourages group cohesion and collaboration. For example, uses humor as relief after a particularly difficult discussion.
   e. Risk Taking: Is willing to risk possible personal loss or embarrassment for success of the overall group or project.
   f. Process Checking: Questions the group on process issues such as agenda, time frames, discussion copies, decision methods, use of information, etc.

   One constructive group behavior I showed was…

8. **Read through the following constructive group behaviors and identify one behavior that you exhibited during the bouncy ball experiment:**
   Destructive Group Behaviors →
   a. Dominating: Uses most of the meeting time to express personal views and opinions. Tries to take control by use of power, time, etc.
   b. Rushing: Encourages the group co move on before task is complete. Gets tired of listening to others and working with the group.
   c. Withdrawing: Removes self from discussions or decision making. Refuses to participate.
   d. Discounting: Disregards or minimizes group or individual ideas or suggestions. Severe discounting behavior includes insults, which are often in the form of jokes.
   e. Digressing: Rambles, tells stories, and cakes group away from primary purpose.
   f. Blocking: Impedes group progress by obstructing all ideas and suggestions. "That will never work because ..."

   One destructive group behavior I showed was…

Bouncy Ball Scientist Information: Personal Power

9. **What is one constructive behavior that you could work on showing more? How will you work on showing it more?**

10. **How can you help other group members show their constructive behaviors more?**

11. **How can you minimize the amount of time you demonstrate destructive behavior?**

12. **Share your thoughts with your group members. Did they have any ideas for how you could improve your group behaviors? Write some of the things they said below:**

Bouncy Ball Scientist Information: Personal Power

13. Now practice the behaviors you can work on through this exercise:

With your group, think about an invention that could help you or society as a whole. The invention needs to use the same scientific principles as the bouncy ball you made earlier. Write down/ draw your group's ideas:

14. Explain how you improved your behavior this time when you worked with your group:

Bouncy Ball Supply List

1. Table spoon measuring spoons → $6.95
   https://www.amazon.com/Tablespoon-Plastic-Measuring-10-Pack-Kitchen/dp/B0754PNVS1/ref=sr_1_8?crid=274VVIZ6CCQYS&keywords=tablespoon+measure&qid=1553785261&s=gateway&sprefix=table+spoon%2Caps%2C222&sr=8-8
2. Plastic cups → $6.31
   https://www.amazon.com/Hefty-Party-Plastic-Assorted-Colors/dp/B00OCGUG02/ref=sr_1_3?keywords=plastic%2Bcups&qid=1553785356&s=gateway&sr=8-3&th=1
3. Borax powder → $7.99
   https://www.amazon.com/MILLIARD-Borax-Powder-Multi-Purpose-Cleaner/dp/B00HLROB6E/ref=sr_1_2_sspa?keywords=borax&qid=1553785411&s=gateway&sr=8-2-spons&th=1
4. Corn starch → $8.99
   https://www.amazon.com/Argo-100-Pure-Corn-Starch/dp/B01E9GXNCM/ref=sr_1_4?crid=I5OJIFW9SROM&keywords=corn+starch+powder&qid=1553785446&s=gateway&sprefix=corn+star%2Caps%2C155&sr=8-4
5. School glue → $21.89
   https://www.amazon.com/Elmers-Liquid-School-Making-Washable/dp/B002FTOBZE/ref=sr_1_4?keywords=school+glue&qid=1553785481&s=gateway&sr=8-4
6. Measuring tape → $9.99
   https://www.amazon.com/Komelon-SL2825-Self-25-Foot-Power/dp/B000BQKXLE/ref=sr_1_5?ie=UTF8&qid=1550464004&sr=8-5&keywords=measuring+tape
7. Large storage kits → $26.93
   https://www.amazon.com/Sterilite-16428012-Quart-Liter-Storage/dp/B002BDTETW/ref=sr_1_13?crid=13UXYKAAQZARI&keywords=storage+bins&qid=1553785583&s=gateway&sprefix=storage+%2Caps%2C416&sr=8-13
8. Latex gloves (child size) → $13.99
   https://www.amazon.com/Kids-Disposable-Nitrile-Gloves-Years/dp/B07JCTCM3M/ref=sr_1_1_sspa?keywords=child+latex+gloves&qid=1553785649&s=gateway&sr=8-1-spons&psc=1
9. Protective eye wear → $11.99
   https://www.amazon.com/JORESTECH-Protective-Polycarbonate-Resistant-Multi-Colors/dp/B0719T6DPQ/ref=sr_1_1?keywords=protective+eyewear+for+kids&qid=1553785706&s=gateway&sr=8-1