REACH FOR THE SKY

FAMILY ACTIVITY

THE POWER OF GLASS

LEARNING OUTCOMES

- **Identify** the material properties of glass.
- **Apply** this knowledge to the design of a glass structure.
- **Design** and **create** a piece of sugar glass.
- **Evaluate** their glass design by testing it in a variety of conditions.

PICTURE THIS...

You are in an elevator that climbs effortlessly into the heavens. You can feel as though you are flying through the sky, but the elevator is enclosed, and you are unable to see how high you have flown above the buildings of Manhattan. After an exhilarating minute, the elevator comes to a halt. The doors open, and you are awestruck by the view. The walls of Edge sky deck are made entirely of glass, and a 360° view of the New York City skyline awaits you. You walk out onto the observation deck and step onto a clear glass panel in the middle of the floor. It's as if you're weightless, floating above the busy streets below. Finally, you walk to the edge of the sky deck. You imagine you have left gravity behind. You are atop a triangle surrounded by glass that angles away from the building, allowing you to lean against it. Looking through the glass at the expansive views that surround you, floating above the city. This is the thrill of visiting Edge.

GUIDING QUESTION

How did the architects and engineers who designed Edge use glass to make a strong, beautiful, and sustainable skyscraper?

ACTIVITY OVERVIEW

In this activity, families learn about one of the most incredible materials known to mankind—glass. They will explore how glass occurs naturally in the environment, learn about the special glass used to build Edge, and make their own glass panel prototype from sugar. Family members will then perform a series of tests to see how well their glass panel demonstrates the physical properties of glass: transparency, heat resistance, chemical resistance, and breakage resistance.

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MATERIALS NEEDED[1]

- graph paper
- pencil
- crayon
- wax paper or parchment paper
- scissors
- 1 cup water
- 3 ½ cups white, granulated sugar
- ½ cup light corn syrup
- ¼ teaspoon cream of tartar
- baking sheet with raised sides
- candy thermometer
- spatula
- cooking spray
- aluminum foil
- straws or wooden skewers
- **Testing It Out** capture sheet
- spray bottle with water
- candle with matches or a lighter

1 Recipe adapted from https://www.wikihow.com/Make-Sugar-Glass

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INSTRUCTIONS

PHASE 1: RESEARCH AND DESIGN

1. What is glass? [2, 3, 4]
    a. You see it everywhere, but have you ever stopped to think about glass? It's a miracle material. Look around your home, and you will almost certainly see glass in every room. Glass shows up in places you expect (such as windows, picture frames, and beverage bottles) but also in places you don't. (Glass is used to make fiber optic cables that help us access the internet, and fiberglass, or glass-strengthened plastic fabric, is probably insulating your house right now.)
    b. Glass is surprisingly hard to define. There are over 350,000 types of glass currently known, and the recipe for each is different. The most basic glass recipes involve sand (silicon dioxide), lime, and soda. As these ingredients are heated and then rapidly cooled, they don't have a chance to form a regular pattern. That's what gives glass its transparent quality.[5]
    c. Did you think that glass was just a man-made material? Think again! Glass occurs naturally. It happens when rocks that have a high content of silica are heated and then cooled rapidly. Volcanic glass is formed when hot magma that seeps out of a volcano cools suddenly. Obsidian, or volcanic glass, was used to make tools and weapons by early humans.
    d. Humans recognized the value of glass early on and have been making it for millennia. It's believed that humans made glass for the first time about 4,000 years ago in Mesopotamia.[6] Glass was made for practical and spiritual purposes.
2. What are the properties of glass?
    a. Glass has four defining properties that set it apart:
        i. Transparency: the ability to see through it
        ii. Heat resistance: its ability to withstand high temperatures
        iii. Pressure/breakage resistance: can be made incredibly strong through a process called tempering
        iv. Chemical resistance: is used in many products because it does not easily corrode or dissolve
3. What sets Edge apart from all other observation decks in New York City?
    a. Glass! Edge allows for an unparalleled experience and 360° views **because** you are surrounded by glass.
        i. Angled glass that allows visitors to lean out over Edge!

2 https://cen.acs.org/articles/95/i47/s-glass-modern-day-researchers.html
3 https://www.glassallianceeurope.eu/en/what-is-glass#:~:text=Glass%20is%20made%20from%20natural,temperature%20it%20behaves%20like%20solids
4 https://www.theatlantic.com/technology/archive/2018/04/humankinds-most-important-material/557315/
5 https://www.theatlantic.com/technology/archive/2018/04/humankinds-most-important-material/557315/
6 https://www.cmog.org/article/origins-glassmaking

ii. The glass floor thrills visitors with the ability to stand 100 stories above busy New York City streets.

iii. The Eastern Point, where the glass panels unite, gives you a feeling of utter weightlessness.

b. The base of Edge has 15 individual sections that are anchored to the building's east and south exterior walls. The strongest section of the entire platform is where the glass floor is placed!

4. Can I make glass at home in my kitchen?

    a. You sure can! With a few common household ingredients, you can make sugar glass at home. Sugar glass has been used in movies for stunts because it is inexpensive and realistic!

5. How do I make it?

    a. Follow the recipe below to create your glass panel. Then, see how your panel does when you subject it to a series of four tests designed to reveal its physical properties. As you develop and test your glass panel, you will be engaging in a process called the engineering design cycle. This is a series of steps that engineers and scientists use to develop new products. The engineering design cycle looks like this:

        i. Research and design

        ii. Prototype

        iii. Test

        iv. Reflect

        v. Refine

6. I'm ready to get started with the first steps of the engineering design process: research and design. What should I do?

    a. Research

        i. This is where it all begins. Researching involves getting background information so that you go into the design process knowing what your product should do and why. There are two key things you must uncover to know where to begin—criteria and constraints. Criteria are the specifications your product has to meet. Constraints are the limitations you must adhere to when building. Here are the criteria and constraints for your glass panel:

            1. Criteria: The panel must be strong enough to withstand the following four tests:

                a. You must be able to see through it when you hold it up to the light.

                b. It must not crack or break when you tap it.

                c. It must not completely melt when you spray it with water.

                d. It must not completely melt when you hold it over a small flame.

            2. Constraints:

                a. Your glass must be made with the recipe provided.

b. Your glass panel must fit on a baking sheet.

c. You can use common household items to strengthen your glass, such as straws and wooden skewers.

d. Your glass panel can be any shape you would like.

e. Your glass panel cannot use reinforcements made of metal or be strengthened with glue or other chemicals.

b. Design

i. Sketch out a design for your glass panel on graph paper.

ii. Trace your design with wax or parchment paper and a crayon. Cut out the paper tracing and place it on the baking sheet.

iii. Use foil to develop a boundary that will help your cooling glass keep its shape.

iv. When you are happy with the shape you created, get ready to make your glass mixture.

PHASE 2: PROTOTYPE

1. Now that I have researched and designed my shape, does that mean that prototyping is next?

a. Yes! It's time to create your glass mixture. Here is how you do it:

i. Start by spraying your baking sheet/foil mold with cooking spray so that the sugar mixture won't stick.

ii. Put the sugar, water, corn syrup, and cream of tartar into a pot. Bring the ingredients to a slow boil over medium heat and stir the mixture constantly. Be careful not to make the mixture too hot, or it will caramelize, or burn.

iii. As the mixture gets hotter, it will turn from cloudy to clear. You will know it's starting to boil when a foam forms on top.

iv. Put a candy thermometer into the pot. Keep the mixture on a low boil until it reaches 300 degrees. (Be patient—this can take over an hour!).

v. When the mixture reaches 300 degrees, slowly pour it onto your baking sheet. Be very careful—it's really hot!

vi. Put your baking sheet on a hard surface and let it cool for about an hour. As it begins to cool, you can add in any strengthening materials, like wooden skewers or straws, to enhance your design.

vii. When the mixture has cooled, run a knife under hot water and slide it gently between the edge of the mixture and the pan. This will help you to loosen your new glass panel from the sheet. When you have loosened it, gently flip the baking sheet over so that your glass panel rests in your hand.

b. Check it out—you have made a glass panel! In the next step, you will see how it performs in a series of tests.

PHASE 3: TEST

1. Write down your hypotheses as to how your glass will hold up to a series of tests on the Testing It Out capture sheet.
2. Use the Testing It Out capture sheet to assess how well your glass structure handles a series of challenges.
3. Conduct each of the four tests, writing your observations on the capture sheet.
4. After you have conducted each test, review your results. Which of your hypotheses came true? What surprised you? Write it down in the table on your Testing It Out capture sheet.

PHASE 4: REFLECT

1. How did your glass survive the testing procedures?
2. What improvements would you make to your prototype?

PHASE 5: REFINE

1. Imagine that you had to create several glass panels that fit together. How would that affect your design?
2. Think about all of the different ways we use glass in our daily lives: we use it to cook food, to make fiber optic cables, to keep us safe in cars and airplanes, and to build our cities. How do the properties of glass make it so useful for all of these very different purposes?
3. As a family, watch The Future is Now Virtual Field Trip and visit Edge at Hudson Yards in-person. While viewing or visiting, look at all of the different ways glass has been used. Pause and observe the different glass structures, taking a moment to appreciate how an ancient material is being used to design one of the most modern and sustainable buildings in the world! Science and engineering helps us envision a more beautiful and sustainable future. How can you harness the power of science to innovate the world around you?

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NATIONAL STANDARDS

Next Generation Science Standards (NGSS)

MS-ETS1-3.
Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

MS-PS1-3.
Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [*Assessment Boundary: Assessment is limited to qualitative information.*]

TESTING IT OUT

INSTRUCTIONS

1. Once your piece of glass is complete, make a hypothesis about how it will perform for each of the four tests listed below. Write your hypotheses in the table under the appropriate column.
2. When you have written your hypotheses, complete each of the four tests. As you conduct the tests, record your observations in the table.
3. After you have completed all four tests, identify the similarities and differences between your hypotheses and the actual test results. Take note of any results that surprised you!

	Hypothesis	Testing Observations	Similarities/ Differences Between Hypothesis and Test
TRANSPARENCY **Test 1:** Hold your glass panel up to the light. Can you see through it?			
PRESSURE RESISTANCE **Test 2:** Hold your glass panel in one hand and lightly tap the front of the panel with your other hand. Does it crack or break?			
CHEMICAL RESISTANCE **Test 3:** Spray your glass panel with five big sprays of water from a water bottle. Does it melt?			
HEAT RESISTANCE **Test 4:** Hold your glass panel about 10–12 inches above the flame of a candle or lighter. Do this for 30 seconds. Does it melt?			