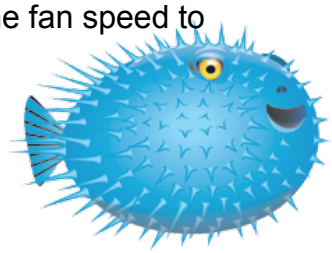
Designs That Survive Storms

Name: Teacher Guide _____ Date: _____

Instructions: Build your model house and test the winds!

1. Gather materials to build a house and engineer storm-resistant features!
    a. **House**: cardboard, scissors, ruler, house template, tape
    b. **Weather hazards**: fan, large tray, water, measuring cup, water pouring device, sponge, measuring cup
    c. **House upgrades**: attaching material (e.*g., playdough, string, paper clips, glue, hot-glue, tape*), waterproof material (*e.g., plant leaves, foil, paint, waxed paper*), lifting material (*e.g., playdough, blocks, chopsticks, small rocks*).
2. Follow the instructions on the house template to create a model.
   (*Note: The house template provides a suggested house design, but you can design your own.*)
3. Place the house on an open surface and direct the fan in its direction. Test the structure and strength of your cardboard house by turning the fan on at low speed. Increase the fan speed to model high wind conditions.



    a. What happened at low speed?
       Results will vary, but in general the roof should stay on the house when the wind speed is low — although if the side of the house is facing the wind, the roof may stay on (see #4 below).
    b. What happened at a higher speed?
       Results will vary, but in general the roof should fly off of the house when the wind speed is high (no matter the orientation).
4. Turn the house so that different sides face the fan and repeat step 3.
    a. Is there a difference? Describe what happened.
       Results will vary depending on how the roof was oriented in #3 above. In general, if the "A" frame part of the house is facing the wind, the roof will fly off — even at low speed (see video 1 in the activity). This is because there is more surface area available for the wind to act on, causing the roof to rise and fly away.
5. Think of a modification to help your house survive better in strong winds and write your hypothesis below: Results will vary, but in general we are looking for students to secure the roof to the house.

Hypothesis: If the roof is tied down (or glued down, or taped down)

then it will be harder for the wind to blow it off.

6. Make the adjustments from above to your structure using the upgrade materials listed in #1.
7. Repeat steps 3-4 to test your modified house against the high winds.
8. Observe and describe what happens.

Flood and Rain Simulations!

9. Place your wind-resistant house in a bucket or other water-catching device.

10. Remove the roof and place a dry sponge inside. Replace the roof.

11. Make it Rain! Use the measuring cup to slowly pour 2-3 cups of water over the house (*Note: Water amount may vary, but be sure to use the same quantity in each trial so you can compare.*)

    a. What happens to the roof?

    Results will vary. The roof may get wet, but most cardboard will shed the rain fairly well.

    b. What happens to the bottom of the house?

    Results will vary, but in general the bottom of the house will get wet due to flooding waters below. Even though the bottom of the house and the roof are made of the same material, the bottom of the house is soaking in water, so it will eventually become wet and saturated.

    c. Can you tell if more water is coming in through the roof or the bottom?

    For most students, more water will come into the house from the bottom.

    d. How could you test your hypothesis?

    Answers will vary. For example, they could try putting an impermeable layer between the roof and the bottom of the house to catch water (e.g., a foil, wax paper, or plastic cover).

12. Remove the sponge from the house and squeeze the water into the measuring cup.

    a. How much water was there?

    Answers will vary, but it should be less than was poured on top!

13. Think of a modification to help your house survive better in strong rains and floods and write your hypothesis below: Answers will vary. Look for students to think of ways to prevent water getting in the house from above and below

    (Note: Remember that water can reach your house from above and below.

    Hypothesis: If I protect the roof from water and elevate my house off the ground

    then less water will get in.

14. Make the adjustments to your structure using the upgrade materials listed in #1.

15. Test your modified house again against rain and flooding. Observe what happens and then write a statement to claim how your engineering design:

    a. How did your design help (or not) the house stay dry in strong rain?

    Water proofing roof example: I used leaves to cover my roof. The leaves have a waxy cover, which stopped rain from coming in the roof.

    b. How did your design help (or not) the house stay dry when the ground was flooded?

    Elevation example: I elevated my house by putting it up on four small rocks. The elevation kept the flood waters from coming in.

Activity Questions

1. Which material or design that worked best to protect your cardboard house against the followng. For each claim, provide evidence and write out your reasoning.
   a. Wind? Answers will vary.
      Playdough worked the best for attaching my roof because I could shape it how I needed to attach the roof.
   b. Rain?
      Covering the roof with leaves kept out the water well. Other covers like plastic also seemed to work well because the rain could not get through.
   c. Flooding?
      Lifting my house up worked the best to prevent flooding because then the water could not get in.

2. In this activity, the rain came straight down and the flood water was not moving. However, during a storm, water can move quickly with a lot of force. How do you think fast moving water would affect your house differently?
   Fast moving rain can come sideways and get windows and walls wet, so the sides of the house has to be protected from water as well as the roof.

3. During tsunamis, a lot of damage can be caused by large objects moving with rushing water. How can we help protect buildings from things like telephone poles and shipping containers washing around in the water?
   Elevating the house will help to protect from flooding and from moving debris.

4. During hurricanes, many people cover their windows with hard material, like plywood. How does this help protect their home?
   Hard covers protect the fragile parts of the house from strong winds, rain, and flying objects. Experts call this "protecting the envelope of the home." It is especially important to protect the windows—so that rain and wind do not get inside the house. If hurricane force winds get inside the house, they can lift off the roof (remember how the direction of the wind affected roof attachment).
5. Describe the area where you live and the types of threats to the home you live in.
   For example, do you live near the ocean, near a stream, or somewhere very windy or rainy?
   Answers will vary. For example, I live on the East side of Kaua'i, about a mile from the ocean and several hundred feet above sea level. My location is very windy and very rainy. My house survived Hurricane 'Iniki in 1992, but water came through my house siding during the 2018 flood, and during very rainy times, my yard and street flood. I am safe from tsunamis but vulnerable to storms.
6. Did native people in your area engineer homes to survive severe storms? What do you think, and what is your evidence?
   Answers will vary. For example, there are historical stories and other evidence that many people on Kauai moved house during different seasons—to take advantage of optimal weather conditions and avoid storms. Rock walls were also used to make strong homes.
7. What types of engineering modifications might help make the home you live in more storm-proof? Answers will vary. My house has roof tie-downs and newer shingles. I am in the process of painting it to help keep out rain water. I do not have window covers. My house would benefit from covers for the windows. I used to have plywood, but it got wet and damaged, so I had to get rid of it. It was also very heavy and hard to put up. I would like to find some strong, light weight material, or build shuttters so that I can protect my windows.