The Cyclone Zone

Objective:

Explain the effects of tornadoes and design a structure to reduce tornado impact.

Overview:

Participants will learn about the effects of tornadoes and strategies engineers use to mitigate tornado destruction.

Each group will compare the aerodynamics of different shapes and modify a house to improve its ability to withstand high wind.

Materials:

Per Group:

- Fan to simulate high wind
- Long strip of paper
- Shapes templates
- Scrap paper
- Tape
- Pencil
- Scissors

Recommended Ages: 10+

Subject Areas: Earth Science, Physical Science, Structural Engineering

Duration: 30-45 minutes

Group Size: 2-5 participants per group

Predicted Cost: $10-$20

Setting: Indoors

NGSS Disciplinary Content: PS2, ESS2, ESS3, ETS1

Key Terms: Tornado, EF Scale, Aerodynamic

Background:

Natural Hazard: Tornadoes

Tornado: occur when air is unstable. Cold air pushes over warmer humid air, creating an updraft as the warm air rises and forming a high-speed rotating column. If this air column reaches the ground, it can intensify and accelerate, forming a tornado.

Tornadoes and Well-Being

Hazards from tornados include:

- Physical danger: debris, damaged power or gas lines, mold from moisture, and other particulates (e.g., asbestos released from structures older than 1980)
- Indirect impacts: overwhelmed infrastructure and health systems

Tornadoes and Infrastructure

Tornadoes are rated based on the damage they cause to infrastructure

Enhanced Fujita Scale, or EF Scale

- Compares damage to set indicators
- Estimates wind speeds produced
- Assigns rating of EF0 (minor damage) to EF5 (incredible damage)

Communities can mitigate damage with:

- Roof clips to stabilize houses
- Underground parts to hold structure in place
- Shatter resistant glass and shutters to prevent wind entering a building
- Dome covers and cylinder roofs that are **aerodynamic** (curved or angled surfaces that improve airflow)

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Preparation:



1. Place a fan (any size) at the end of a long table. It is recommended to use one fan per group.
2. Tape the long strip of paper along the table. Place one end about 5" (12.7 cm) away from the fan. The length of paper depends on the strength of the fan, but about one yard (one meter) long should be enough.
3. If working with a primarily younger group, it is recommended to print out and preassemble the shapes. Otherwise, groups assemble their own shapes during the activity.

Procedure:

1. Using the graphic provided in the resources, introduce participants to the EF scale.
2. Older groups: pass out shape templates and allow time to assemble shapes. Younger groups: pass out shapes.
3. Working one shape at a time, each group will place a shape in front of the fan at the beginning of the paper strip, turn on the fan, and mark on the paper how far it went.
4. As a whole group, discuss which shapes moved the least. These shapes are more aerodynamic.
5. Point out how, even though it was least aerodynamic, most buildings are rectangular prisms, or boxes. Groups will now improve their box to keep it from being moved by the wind.
6. Provide groups with scrap paper and tape. Any changes are allowed, but the base structure must remain a rectangle.
7. When groups are ready, test their new structure. Compare the new distance to their mark for the original box.
8. As a whole group, discuss the different strategies for improving the box. Connect as many as possible to real engineering solutions used in housing development.

Engineering Connections

- Taping the box to the table is like building part of a structure underground.
- Changing the top of the box is like using steepled, cylindrical, or domed roofs.
- Using tape to attach the roof or any new components is like using roof clips.
- Reinforcing the box to add weight is like adding shutters or a sturdier foundation.

Extensions and Modifications

- If modifying for a tabling event, display EF rating information in resources to discuss the EF scale and damage levels. Either allow visitors to test out each shape or provide materials to make a building they think can withstand the wind.
- Instead of testing different shapes first, groups can just be given access to templates, blank paper, and challenged to make the most aerodynamic structure within a certain size.
- This activity can be connected to "Betting on Biodiversity" and "The Particulates of Air," using the Tornadoes and Human Impact document in the resources.

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Enhanced Fujita Scale for Tornados

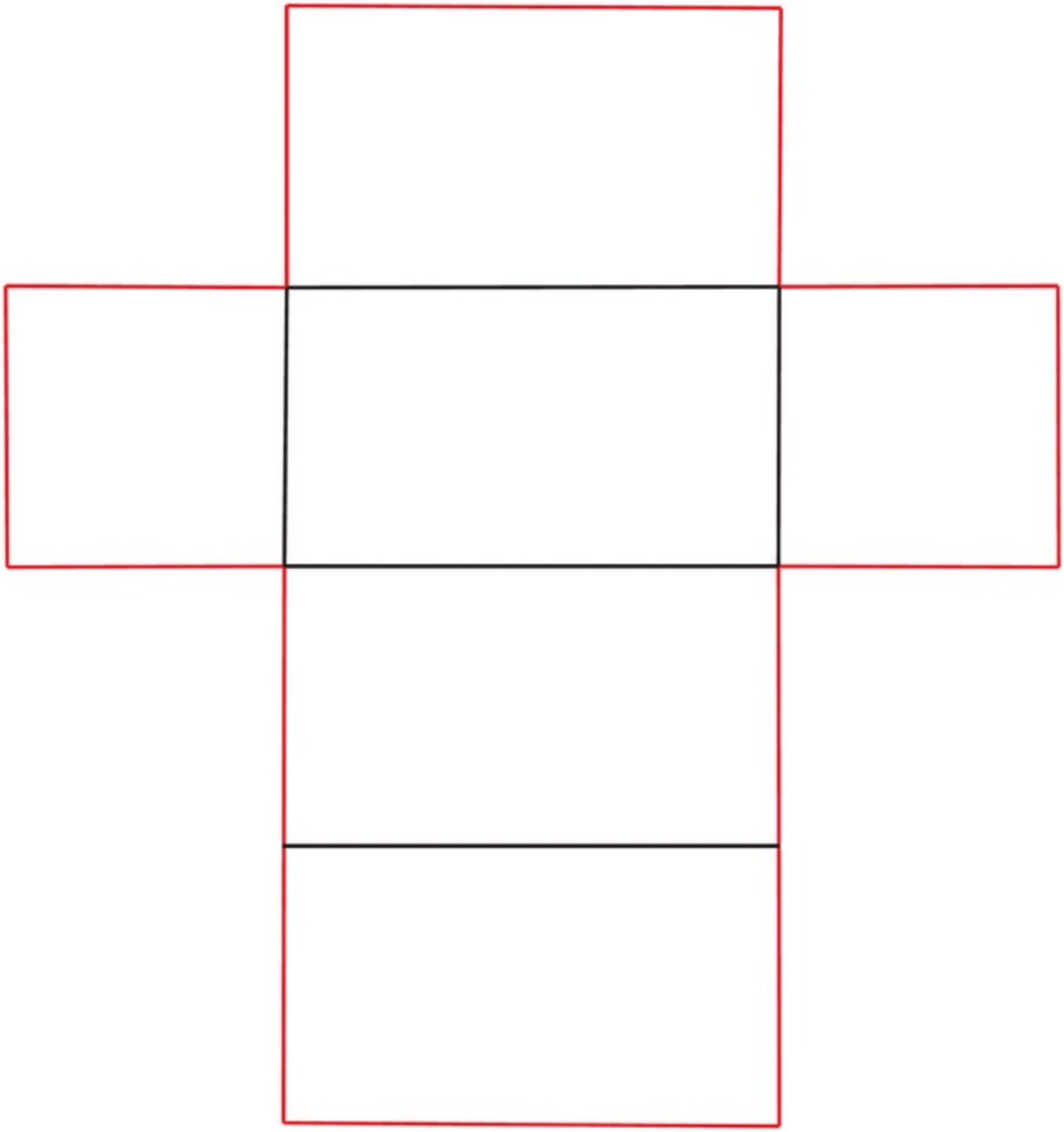
The Enhanced Fujita Scale (EF), introduced in 2007, provides estimates of tornado strength based on damage surveys. The original scale was developed by Dr. Theodore Fujita and implemented in 1971.

Wind Speed	EF Scale	Typical Damage
65-85 mph	0	-Light damage -Can peel surface layers off the roof -Branches broken off trees -Shallow-rooted trees pushed over -Sign boards damaged
86-110 mph	1	-Moderate damage -Roof partially torn off houses -Windows & glass doors broken -Moving cars blown off road -Mobile homes demolished
111-135 mph	2	-Considerable damage -Roof completely torn off houses -Frame houses shifted off foundations -Large trees snapped / uprooted -Cars lifted off ground
136-165 mph	3	-Severe damage -Some walls torn off houses (roof gone) -Trains overturned -Cars & other large objects moved short distances
166-200 mph	4	-Devastating damage -Well-constructed houses destroyed -Cars and other large objects tossed around immediate area
200+ mph	5	-Annihilation-level damage -Frame houses completely flattened -Brick/concrete buildings wiped off foundations -Cars thrown long distances

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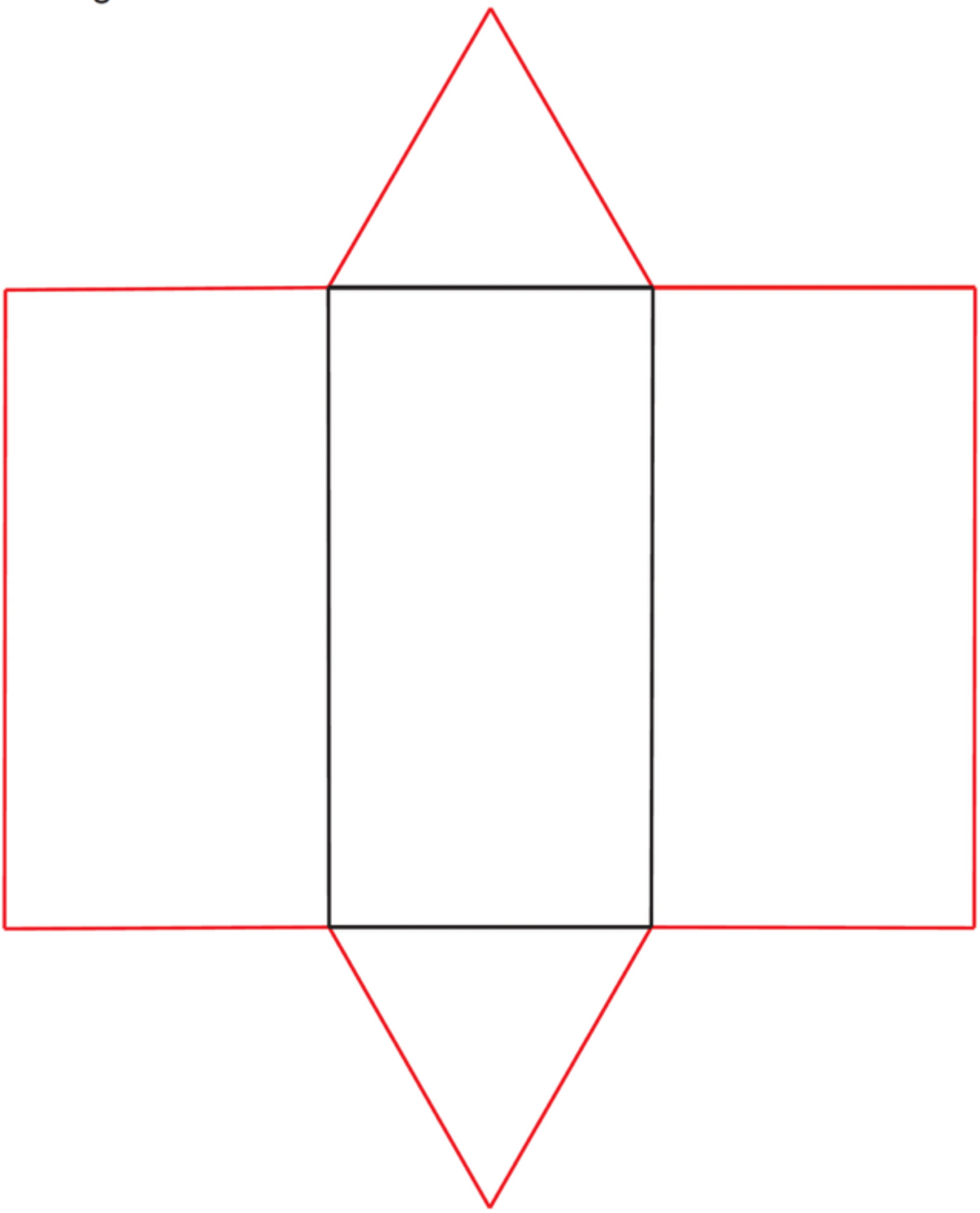
Shape Templates

Rectangular Prism



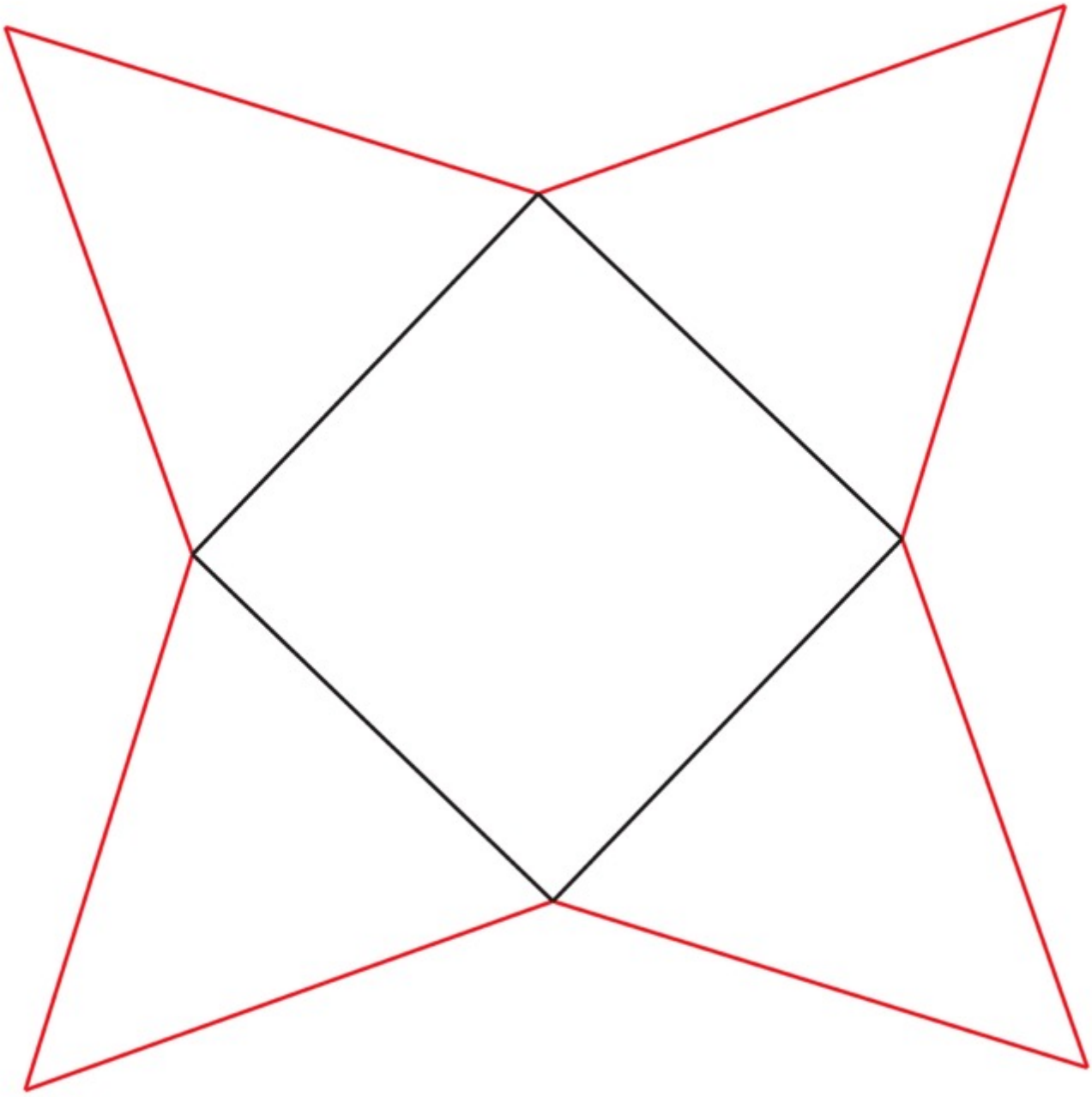
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Triangular Prism



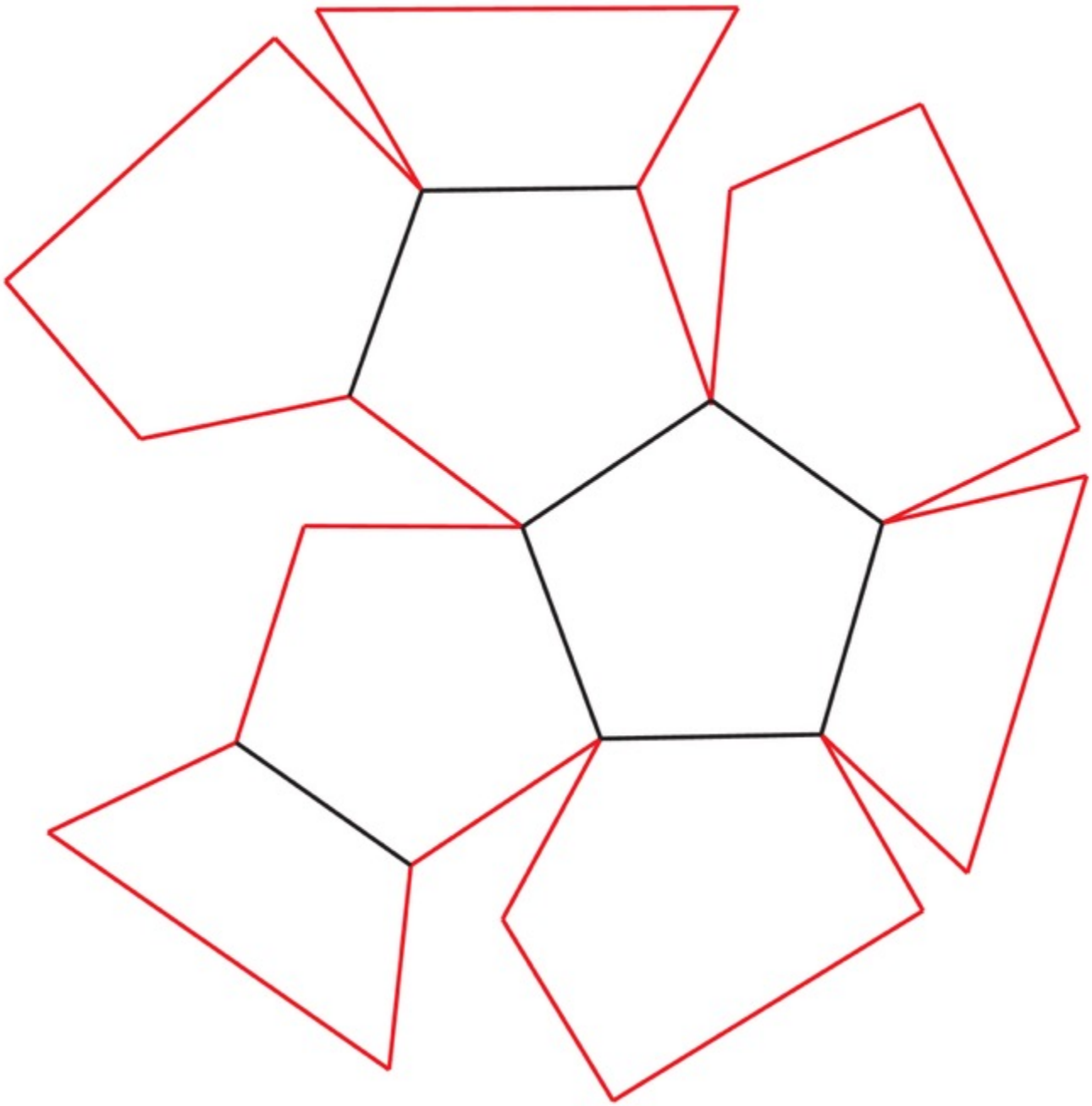
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Pyramid



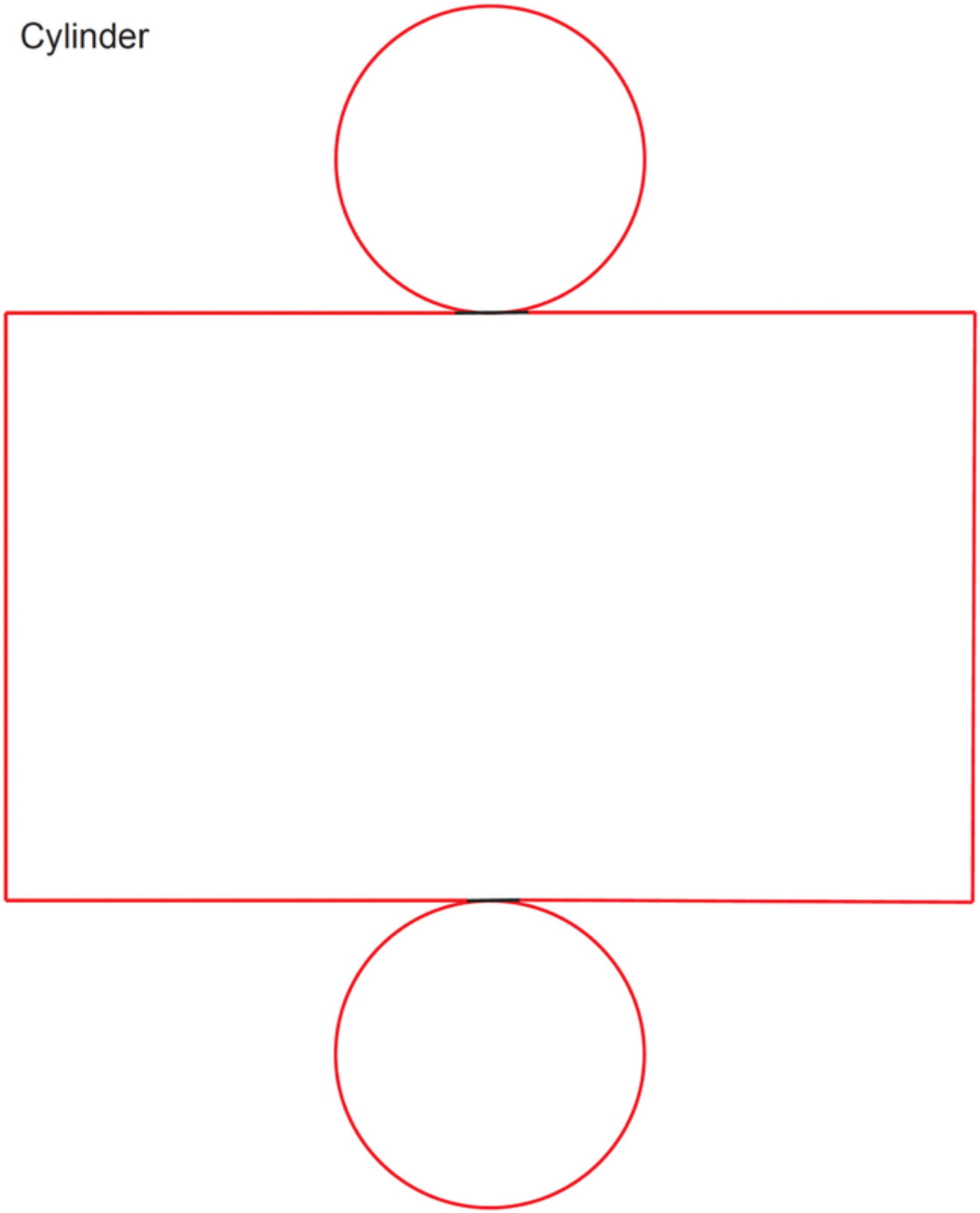
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Dome



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Cylinder



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Tornadoes and Human Impact

The key ingredients of a tornado are moist air at ground level, cool dry air higher up, and the change in wind speed or direction. Each of these can be affected differently by climate change.

Connection to Air Particulates *(see "The Particulates of Air" activity)*

Warmer air supports more particulates in the atmosphere. Extreme heat and stagnant air increase the amount of ozone pollution and particulate pollution in the air. Having more particulates suppresses rain and evaporation of more water to the surrounding air which, in turn, increases the humidity of the surrounding air. This provides a more favorable environment for the formation of thunderstorms and therefore increases the chance for tornadoes.

Particulates like the smoke from wildfires lower the base of the clouds and increase *wind shear*, defined as wind speed variations with respect to altitude. Together, those two conditions increase the likelihood of more severe tornadoes. Surprisingly, most severe weather prediction centers do not currently include atmospheric particles and their effects in their models – but they should!

Connection to Biodiversity *(see "Betting on Biodiversity" activity)*

With smart, responsive recovery efforts and good environmental planning, ecosystems can recover and infrastructure can be repaired and improved to withstand future storms. For example, in tornado-affected areas, replanting of tree species selected for wind resistance and sustainability can help reduce future storm impacts. Cities that prioritize forestry & landscape management as part of their storm response units tend to have urban forests that recover faster -- recovery can begin immediately, many trees are saved, costs are minimized, and overall results are highly effective. Plants also anchor dirt so that it doesn't fly around as much during lower EF-rated tornadoes.

Areas that are damaged by tornadoes are susceptible to invasive plant takeover. Research shows that, to help forest and green spaces recover more fully, land managers should focus their eradication treatments on the most abundant invasives in their system.

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