DAY 10

Winter Disasters

STEM CONNECTIONS

Engineering: Defining Problems & Developing Possible Solutions

DURATION

60 Minute Lesson

MATERIALS

- **Flour** (¼ cup per group) *optional, for extension*
- **Marshmallows** (about 40 per group)
- **Tetrahedron, cube and dome models** (prepare ahead of time)
- **Toothpicks** (about 50 per group)

SCHEDULE

- Winter Disasters (15 min)
- The Tetrahedron and Cube (5 min)
- Geodesic Dome Challenge (30 min)
- Wrap-Up (10 min)

OBJECTIVE

Continue investigating the delicate engineering of roof design.

ALIGNED STANDARDS

NGSS

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

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.

21ST CENTURY SKILLS

- Initiative and Self-Direction
- Productivity and Accountability

HABITS OF MIND

- Applying Past Knowledge to New Situations
- Striving for Accuracy
- Remaining Open to Continuous Learning

KEY TERMS

- **Blizzard:** a severe snowstorm with high winds and low visibility.
- **Polyhedron:** a solid figure consisting of four or more plane faces (all polygons).
- **Tetrahedron:** also called a triangular pyramid, it is a polyhedron composed of four triangular faces, six straight edges and four corners.
- **Geodesic Polyhedron:** a dome or sphere shaped three-dimensional structure with faces made up of triangles.

BACKGROUND INFORMATION

Winter conditions are some of the most inherently dangerous weather we deal with on a yearly basis. From sub-zero temperatures to blizzards, meeting Jack Frost can come with a devastating bout of frostbite. These wintery conditions can also cause a lot of harm to structures outside of your body. Heavy snow, whipping winds — it takes some fine engineering to design a home capable of withstanding a blizzard and the severe weight of snow.

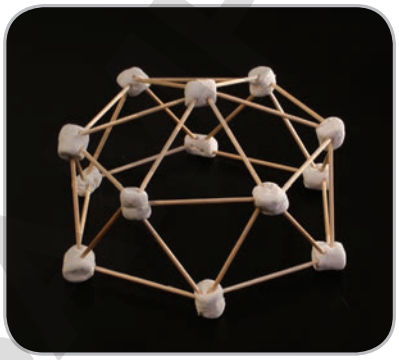
Just like with volcanic ashfall, buildings constructed in areas that get a lot of snowfall need to be able to withstand the added weight on their roofs. One of the best ways to mitigate that weight is with a particularly stunning design called a geodesic dome, or sphere shaped three-dimensional structure with faces made up of triangles. As we know, triangles are inherently stable and strong shapes, so when a dome is created out of interlocking triangles, the strength of each triangle combines into an incredibly stable and lightweight structure! Think of an egg. Eggs have a thin skin, but they're capable of resisting a pretty spectacularly large load. This is because domes distribute loads in a three-dimensional direction instead of the the two load direction of traditional homes and roofs.

Today, campers will explore the incredible strength of geodesic polyhedrons with a Geodesic Dome Challenge!

DAILY PREP

- Gather materials and review the lesson to prepare for any geodesic-based questions.
- Make toothpick and marshmallow models of a tetrahedron, cube and geodesic dome.





NOTE: keep the dome hidden from view until well into the construction process when the groups have had the opportunity to try to arrive at a dome design on their own.

Group Discussion

WINTER DISASTERS

Welcome back to *Build a Better World Camp*! The previous lesson on live load limits ties directly to today's lesson, which focuses specifically on one kind of structure that holds up particularly well to snow loads. Start the day off by reviewing which roof shapes were best and why they did a good job dealing with an increase in live loads. Then, transition into a winter disaster discussion by posing these questions, using the Background Information to feed the conversation:

- What disasters come with winter? (Blizzards, freezing temperatures, heavy snow, icy roads.)
- What is a blizzard? (A severe snowstorm with high winds and low visibility.)
- Why is snow such an issue? (It's heavy, cold, slick, etc.)

Have you ever shoveled a driveway after a big snowstorm? That snow is very heavy, which is why some homeowners need to shovel their roofs to keep the weight of the snow from caving it in. Just like with ashfall, some roofs are better designed to handle the weight of snow. Most ski lodges have very sharp sloped roofs to naturally let gravity pull the snow off the building, but other snow buildings rely on a different shape altogether. We're talking about igloos. Igloos utilize a three-dimensional dome shape to help spread out the weight of the snow. Over the years, engineers have worked with this dome shape, creating a near-perfect version called a geodesic polyhedron.

With questions swirling about polyhedrons, transition into the Tetrahedron and Cube discussion.

Group Discussion

THE TETRAHEDRON AND CUBE

Discuss the key terms with the class, and show them the tetrahedron and the cube you build ahead of time. For now, hold back the dome, as you want to give the groups time to explore the possibilities for building one on their own before sharing it. Make sure to emphasize that all polyhedrons are made of polygons (flat shapes with straight edges) and that there are many possible shapes they could choose to make their buildings. Then, show campers the example photos at the end of this lesson.

Answer any questions they may have, and remind them what they have learned about what the strongest shapes are (i.e., triangles are stronger than squares!) Then, transition into the Geodesic Dome Challenge.

Small Groups

GEODESIC DOME CHALLENGE

Separate campers into their groups and pass out materials. Then share the challenge rules with the class:

- Begin by creating a tetrahedron and a cube.
- Compare their relative stability by pressing down gently to see how they move.
- Then build a geodesic dome with faces made of triangles only.
- You can use as many of your toothpicks as you want, and you have the freedom to design the base however you want.
- If you need more supplies, take apart your cube and tetrahedron.

As they work, make your way around the room, observing their constructions and encouraging them to share their ideas. About halfway through the allotted time, show the example dome you created to any groups who are still struggling to get a dome started. Use your best judgment to strike a balance between letting them fail forward and preventing excessive frustration.

Group Discussion

WRAP-UP

Once time is up, show the class the dome model you created. Ask groups to share their domes, and discuss the similarities, differences and what strategies they used to build their domes.

Then have the class return any marshmallows they didn't use to a resealable bag for use on Day 12, and collect their domes. When they come in the next day they will be even sturdier, and you can share them during the recap at the beginning of Day 11.

CHECK FOR UNDERSTANDING:

1. What is a polyhedron? *(A three-dimensional shape made of flat faces with straight edges.)*
2. Why would a geodesic dome be a good building choice for places where blizzards are a regular hazard? *(They are made of triangular faces, and can withstand heavier live loads than other shapes.)*

EXTENSIONS:

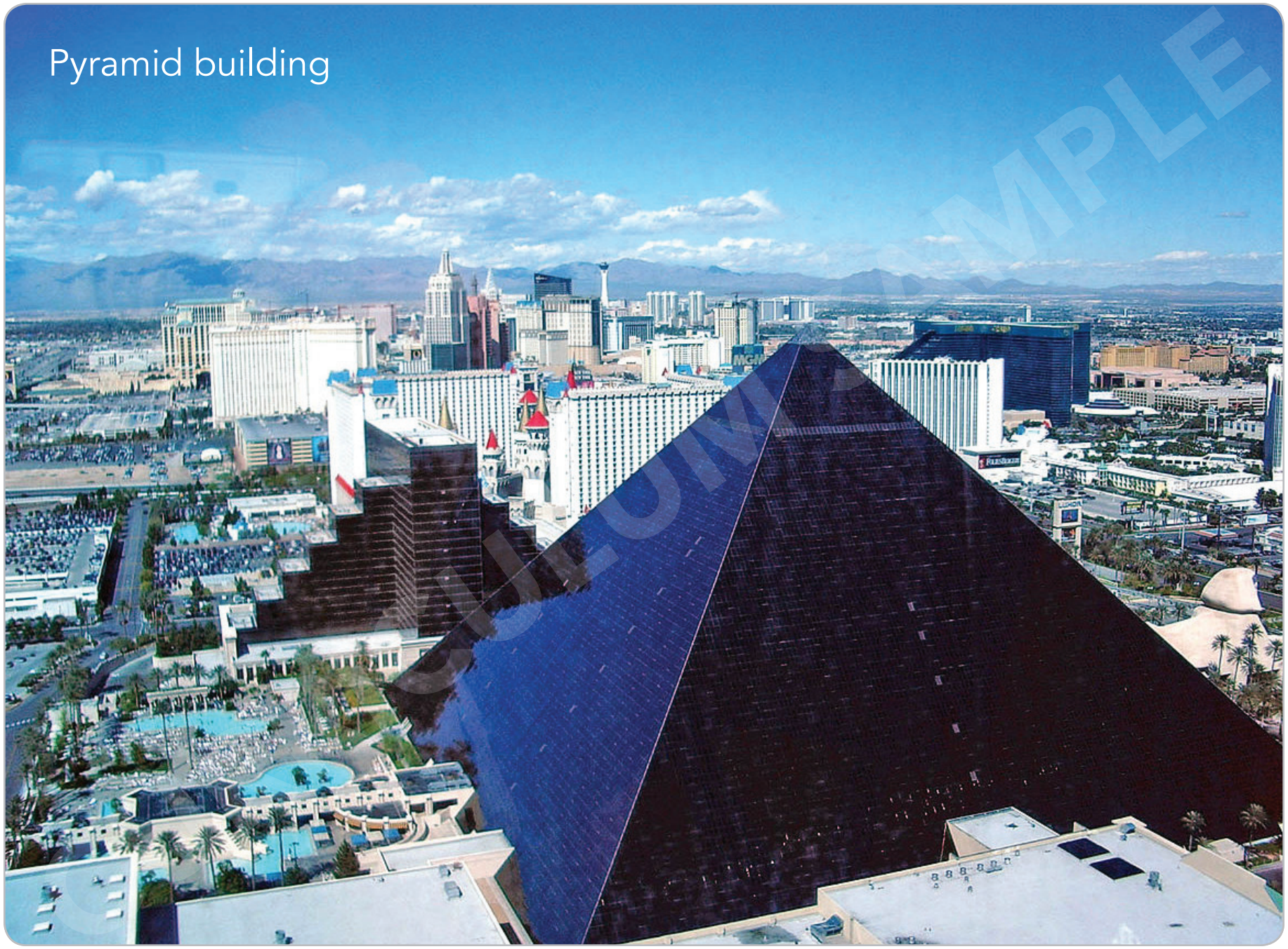
Have campers cut out triangles from notecards to cover their geodesic domes, then sprinkle the included flour over them to simulate snow falling during a blizzard.

OR

Have campers research which shapes of buildings usually have the most usable space, and have them explain why.

Rectangular building

Pyramid building



Geodesic sphere