Unit 3 (Structures):
Making a Strong Frame

Concept
We can build a frame as a basic strong structure with wood and cardboard right triangles. The frames can be expanded into a box shape.

Teacher Preparation
Copy the design problem onto colored paper. Make a sample frame (see Figure 12, Teacher Handbook, p. 22).

Content Objective
Students use cardboard right triangles and adhesive to construct two basic wood frames the same size. The students add on to their wooden (flat) frames to make a wood box frame.

Language Objective
Use drawings and sentences to strategically demonstrate understanding of structures, using adjectives (e.g., *strength, weakness*).
Describe actions using *present progressive tense (verb+ing).*
Summarize the box construction using *past tense verbs*.

Standards
- **NGSS:**
  - **2-PS1-1.** Plan and investigate kinds of materials and their observable properties.
  - **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define problem that can be solved with a new or improved object or tool.
  - **K-2-ETS1-2.** Make a drawing or physical model to illustrate how the shape of an object helps it to solve a problem.
  - **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses.
- **TEKS:**
  - **2E** communicate observations and justify explanations using student-generated data from simple descriptive investigations (justify explanations of own data)
  - **4A** collect, record, and compare information using tools, including computers, hand lenses, rulers, primary balances, plastic beakers, magnets, collecting nets, notebooks, and safety goggles; timing devices, including clocks and stopwatches; weather instruments such as thermometers, wind vanes, and rain gauges; and materials to support observations of habitats of organisms such as terrariums and aquariums (use tools)
  - **5A** classify matter by physical properties, including shape, relative mass, relative temperature, texture, flexibility, and whether material is a solid or liquid (phy prop: shape, mass, temp, texture, flexibility, solid v. liquid)
  - **5D** combine materials that when put together can do things that they cannot do by themselves such as building a tower or a bridge and justify the selection of those materials based on their physical properties (combine materials for purpose)

- **ELPS:**
  - **1C** use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary (strategic learning techniques such as concept mapping and drawing)
  - **3C** speak using a variety of grammatical structures, sentence lengths, sentence types, and connecting words with increasing accuracy and ease as more English is acquired (speak using a variety of grammatical structures)
  - **5E** employ increasingly complex grammatical structures in content area writing commensurate with grade-level expectations, such as using correct verbs, tenses, and probnouns/antecedents, using possessive case correctly, and using negatives and contractions correctly (employ increasingly complex grammatical structures including, i. tenses)
  - **5G** narrate, describe, and explain with increasing specificity and detail to fulfill content area writing needs as more English is acquired (narrate, describe, explain through writing)

Materials:
Wood strips; craft or popsicle sticks; low temp glue gun; glue sticks; wood glue; right triangle corners, cut paper shapes for triangle blueprints; newspaper to protect gluing table surface; crayons and paper; sample frame and one box frame sample; other construction materials such as cardboard, posterboard, construction paper; fan or hair dryer to test

Suggested Literature Connections
"Buildings and Structures" by Andrew Solway
"Building the Empire State Building: An Interactive Engineering Adventure" by Allison Lassieur

Day 1: Engage/Explore Structures-Making a Frame and Box

Teacher Says/Does	Student Says/Does	Language requirements
1. Ask students to share their recollection of the story of the *The Three Little Pigs*. Discuss the structures of the three houses the pigs made. Distribute handout (**2.3.1**) with questions to student pairs and ask them to think of answers to each of the following questions: • *Why was the wolf able to blow down the house that was made of straw?* • *What makes a material strong?* • *Why did they get blown over?* • *Which way was the force of the wolf breath pushing on the structure?* 2. Give a few minutes for discussions, and then have student pairs share their ideas with the rest of the class. 3. Explain how strength is important in structures we build and how that strength allows the structures to hold different shapes. 4. Show the Zoom video on *Finding the Strongest Columns*: http://www.pbslearningmedia.org/asset/phy03_vid_zcolumnsi/ Ask what happened to the rectangular column. Emphasize the importance of materials and shape in making a strong structure. 5. For demonstration, consider using different paper shapes to compare the way they hold weight (i.e. a 2D rectangle vs. a 3D prism). Discuss strength in the little pigs' houses, school buildings, etc. 6. Tell your students that triangles can be used to make a type of frame that can be used to reinforce structures.	Students discuss the questions in pairs. Student pairs discuss what happened in the video.	The wold was able to blow down the house that was made of straw because _____. The strength of his blow breath was pushing _____. A material is strong when _____. The wold was not able to blow down the house made out of bricks because _____. Vocabulary: structure, predict, even, edges, frame

7. Show the video that highlights the importance of using triangles in bridges: https://www.youtube.com/watch?v=oVOnRPefcno 8. Show the students a sample frame you have made, and point out the triangles in the corners. See handout (**2.3.2**) as reference. 9. As a class, construct a similar frame, using adhesive to hold the right triangle corners onto the junction of each pair of rectangular pieces. You may want to create a paper blueprint for the construction of the triangles and/or frames. Model the use of active language as you work (making, gluing, pressing, etc.). 10. In pairs, ask your students to think of similar frames that they have seen in the "real world." Use handout (**2.3.3**).	Students draw three examples of frames from their house or the school.	

Day 2: Explain/Elaborate Structures-Making a Frame and Box

Teacher Says/Does	Student Says/Does	Language requirements
1. Tell your students that they will now be engineers themselves and design and construct houses (similar to *The Three Little Pigs*) using different types of frames like the ones they constructed. Their houses can either be rectangular or not. The purpose is for students to explore the strength of frames and how these can be assembled to create a structure. Do not give too much importance on the ahestetics of the house. 2. To recall previous knowledge, ask the students to think and share what a stable house needs. 3. Consider the following additional requirements: • The pig house stand in the same place after a wind (hairdryer or fan) has blown on it. • The pig house must resist some sort of weight (stapler, wooden blocks, etc). 4. To maintain fairness, tell your students that the same amount of time and distance will be used for the fan or hairdryer (wind test), and the same weight will be applied for the same amount of time to all the houses (resistance test). 5. *Optional.* You may wish to add a constraint that the houses are about the same size. You can do this by saying that the "footprint" of the house be not bigger than 6" by 6" (15 cm x 15 cm). This means that the base of the house will fit exactly onto a square that size. You may also wish to have a height limitation. 6. Organize students in pairs or groups as convenient and give them the following design brief:	Student pairs discuss. Student teams complete their design briefs. Student groups start work on their boxes. Students take notes on their vocabulary sheets.	Vocabulary: structure, predict, even, edges, frame

Design Brief: Design and construct a “house” that can withstand wind and weight 7. Give each pair/group a copy of handout (**2.3.4**), and talk with partners or within their groups to resolve any meanings, and plan who will do the different jobs. 8. Have teams start creating a plan for their model. Tell them to make several preliminary sketches, select one, and make a labeled sketch that can be used to present to the class. 9. Finally, let teams work on their houses. 10. Encourage your students to construct their houses using frames made of any materials that they want (paper, cardboard, straws, tape, etc). 11. Discuss additional uses/forms of the vocabulary words, such as: prediction, predicting, framing, ‘even’ in math different from ‘even’ here meaning ‘level’ and ‘smooth.’		

Day 3: Evaluate Structures-Making a Frame and Box

Teacher Says/Does	Student Says/Does	Language requirements
1. Before testing, model the process of summarizing the steps of the project of an individual pig house. Use handout (**2.3.5**) as a reference. Draw attention to the regular and irregular past tense verb forms like: • *Glued* • *Built* • *Stuck* • *Looked* • *Connected* • *Worked*	Student pairs first discuss their answers, and then share in the whole group.	Vocabulary: stable, wind resistance, sturdy, weak
2. When they are finished, have them evaluate their houses with you, using some of the questions such as: • *What shapes do the faces of your house makes?* • *Did you use triangles to make your frames stronger?* • *What materials is your house made from? (wood, paper, glue)* • *What kinds of fasteners did you use to hold pieces together? Would these fasteners work on a real house?* • *What were some obstacles the team had to figure out before they could finish the house?*	With the assistance of the teacher, students test their structures. Students participate in a discussion about stability.	Regular and irregular past tense verb forms
3. It is time to test the houses! Go ahead and handle the air supply and weight and test each team pig house for stability.		
4. At the end of the tests, ask your students questions like: • *Which structures are more stable? Why?* • *Which frames were the most stable? The ones with triangles? Tape? Other materials?*		

• *Which shapes (triangles, squares, circles) seem to make structures that are best balanced—that is, they do not easily fall over?* 5. Have student pairs write a summary of their projects using the flow chart (handout **2.3.6**). Have student groups present their unique process to the rest of the class.	Student teams write a summary in the flow chart using past tense verbs.	

Name: _____ Date: _____

Strong vs weak materials

The wolf was able to blow down the house that was made of straw because _____

_____.

The strength of his breath was pushing _____

_____.

A material is strong when _____

_____.

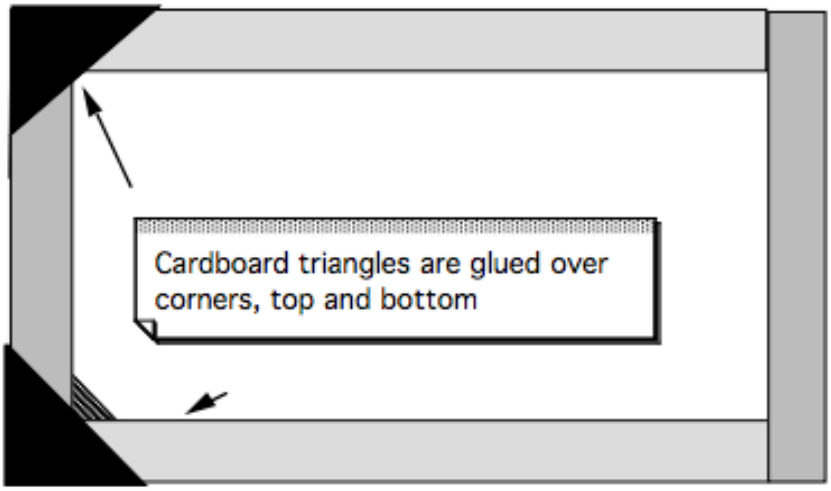
The wolf was not able to blow down the house made out of bricks because _____

_____.

(Teacher Reference)

Basic Wood Frame with Cardboard Triangle Corners

HOW TO MAKE SOME



MODELS

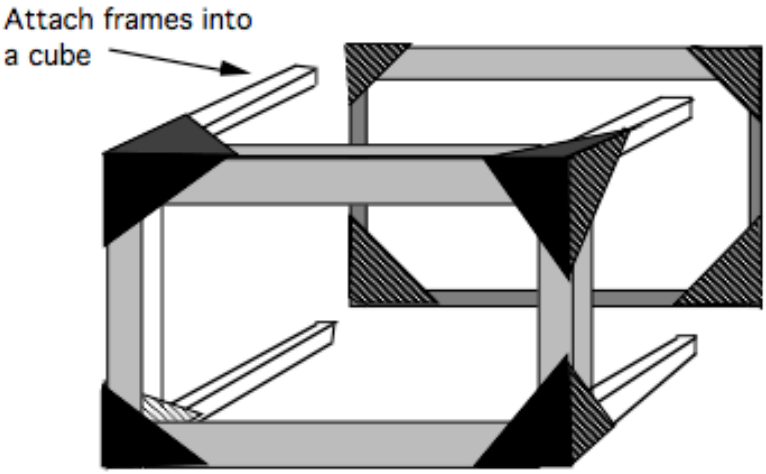


FIGURE 12. CONSTRUCTING A FRAME

Name: _____ Date: _____

Examples of Frames

Instructions: Draw 3 examples of frames using triangles that you can remember seeing in the past.

Drawing of example 1

Drawing of example 2

Drawing of example 3

Name: _____ Date: _____

Design Brief: Making a strong structure

Design Problem	Words to Remember/ Palabras para recordar
Design and construct a "house" that can withstand wind and weight.	• Structure • Predict • Even • Edges • Frame • Resist

Drawing or Model of Our Plan (You can use the back of the page, too!)

Steps	
Task	**Person Responsible**

Name: _____ Date: _____

Creating a strong structure

For this design brief, we wanted to create _____.

To do this, we first need to_____

_____.

Second, _____

_____.

Then, _____

_____.

After that, _____

_____.

Finally, _____

_____.

Name: _____ Date: _____

Instructions: Summarize your process of creating your "house" by thinking about EVERYTHING you did and writing only the most important parts in order.