Unit 2 (Structures):
Investigating Types of Loads

Concept
Structures experience a variety of forces, including compression, tension, torsion, and bending.

Content Objective
Investigate properties of a variety of structures and forces and lead a structural tour of the school.

Language objectives
Provide examples that reflect understanding of the word "*structure*" as part of classroom discussions.
Describe objects that exhibit "*compression*", "*tension*", and "*torsion*" using prepositional phrases.
Orally discuss investigations into building columns and beams with classroom objects using comparative adjectives.

Standards

- **NGSS**:
    - **3-5-ETS1-1**. Define a simple design problem, including criteria for success and constraints on materials, time, or cost.
    - **3-5-ETS1-3**. Plan and carry out fair tests that control for variables and identify failure points to improve a model or prototype.
- **TEKS**:
    - **2A** Students will plan and implement descriptive investigations, including asking well-defined questions, making inferences, and selecting and using appropriate equipment or technology to answer his/her questions.
    - **2B** Students will collect and record data by observing and measuring, using the metric system, and using descriptive words and numerals such as labeled drawings, writing, and concept maps.
    - **2C** Students will construct simple tables, charts, bar graphs, and maps using tools and current technology to organize, examine, and evaluate data.
    - **2D** Students will analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.
    - **2E** Students will perform repeated investigations to increase the reliability of results.
    - **6D** Students will test the effect of force on an object such as a push or a pull, gravity, friction, or magnetism.

- **ELPS:**
    - **1A** Students will use prior knowledge and experiences to understand meanings in English. [Prior Knowledge]]
    - **1C** Students will use strategic learning techniques, such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary. [Metacognitive Strategies]
    - **3H** Students will narrate, describe, and explain with increasing specificity and detail as more English is acquired.

Materials

- A variety of 8 potential structural components for children to test that might include bread, spaghetti noodles, plastic building blocks, clay, plastic, paper, cloth, socks, cardboard, rock, drinking straws, popsicle/craft sticks, wood dowels, aluminum foil, and such; each item is to be cut or combined and shaped by students to be approximately the same size [Suggested size is: 2"x 1" x 1/2" (5 cm x 2.5 cm x 1.25 cm)]
- Chart to serve as a key showing the reference numbers for the materials to be tested
- Lesson handouts **4.2.1- 4.2.4**

Literature Connection

If I Built a House By: Chris van Husen

Day 1: Engage/Explore

Teacher Says/Does	Student Says/Does	Language Requirements
1. Show students a corrugated cardboard piece and let them see the pleated paper between the cardboard layers that give it strength. Have pairs discuss how that pleated paper is part of the structure of the cardboard. 2. Let students share opinions to answer the following questions: o Where are pushes and pulls happening on a box of cookies or crackers? o What do engineers invent to solve problems like crushed cookies? o Which containers are breakable? Which are permanent? Which are temporary? 3. Tell students that structures are the shapes and supports that keep things strong. Some structures also provide space. Structures have different parts and have different shapes. Structures are objects built to provide support. 4. Discuss how structures can be rigid or flexible, durable or breakable, permanent or temporary. Analyze the meaning of each attribute with specific examples. Have students provide additional examples in each case. 5. Show students structures with a prism, a cylinder, a cone, and a triangle. Ask them to compare them in terms of their strength and other properties. 6. Ask students to describe some of the structures they know about in the classroom and outdoors. Make a list as they talk. 7. Place students in pairs and have them describe a favorite structure using the handout provided (**4.2.1**); later, have each pair share their structure with the class.	Students analyze characteristics of structures Student pairs choose one structure, write about it, and then share with the rest of the class	Structures Cubes Frames Chassis Braces Strength Stability Balance Rigid Compression Tension Torsion

Day 2: Explore/Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. Provide teams of two with a copy of Resource Page F, "Structures Web", **4.2.2**. 2. Point out the boxes next to each word on the web. Explain that their team will need as much information as possible about structures in order to be successful on a bridge building activity coming up. Therefore, their team will write or draw examples of each idea in the boxes. Teams should think about whether the structures are *natural* (made by nature) or *built* (made by humans). 3. After a team of two has finished some of the examples on their web, have them join with another pair to form a group. They should then compare and continue filling in web examples.		

Day 3: Explore/ Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. Write the words “compression”, “tension”, "torsion", and "bending" on a chart, and tell the students that these are forces that work on structures. 2. Compression is force squashing a structure and tension is force pulling on it. Show students a Nerf or other soft ball and squeeze it, while having the students say “compression.” (“Compress” and “compressed air” are related words that may be familiar to some students.) 3. Ask a student to demonstrate how the ball acts when tension forces are used on it. (She or he should try to pull the ball apart.) The ball does not stretch much; it probably does not break. 4. Ask the students why the Nerf ball needs to be compressible. (so that it will bounce, and so that it can be thrown indoors) 5. Have students try to name some pulling forces that they know (pulling a wagon, e.g.) and tell what materials are used and why. 6. Tell students that materials are also subjected to torsion forces, which are twisting forces. 7. Ask students to provide examples of objects that bend. 8. Ask students to provide examples of objects that can be compressed, objects that can be stretched, and objects that respond well to torsion. 9. Have students begin on investigations based on the Performance Test Handout (**4.2.3**). Show them the chart, explain it, and then have groups identify 8 objects to collect and to test for performance under compression, tension, bending, and torsion loads. Teams can work on the web as they carry out their investigations. 10. Start a chart to combine the findings from the investigations and pool results. Use table in **4.2.4** to tabulate results.	Students become familiar with the meaning of compression, tension, bending, and torsion Students provide examples of objects that show compression and torsion, as well as objects that can bend and respond to torsion Students investigate compression, tension, and torsion with familiar objects	Compression Tension Bending Torsion This object shows (compression/tension) because _____. This object bends because _____. This object's response to torsion is _____.

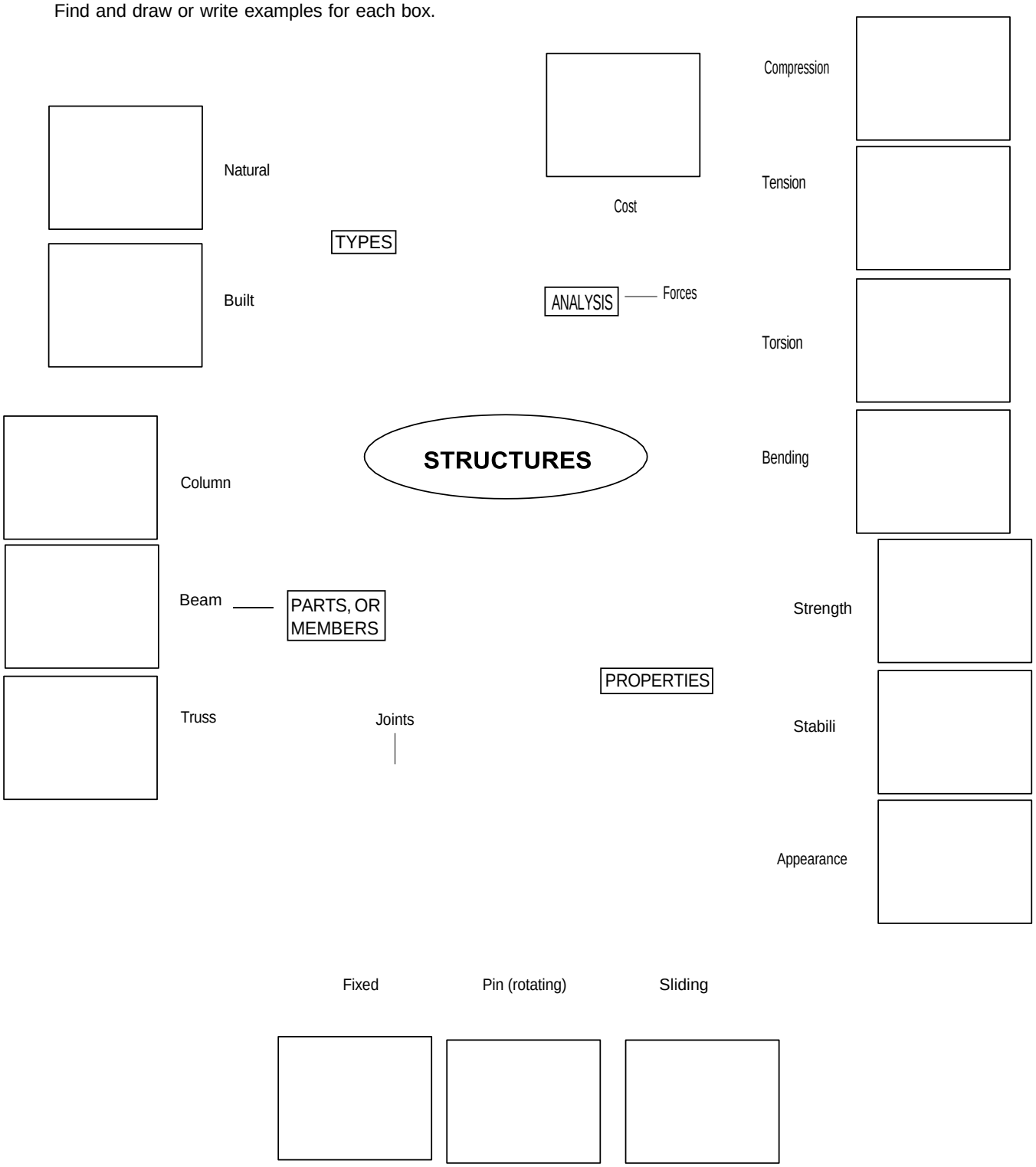
Day 4: Elaborate and Evaluate

Extensions into the Disciplines	Practical Extensions	Language Requirements
1. As a conclusion to what students discovered previously about forces and loads on structures, have student teams take a tour of the school building. Each team can mark off five examples for each type of structural part (and maybe a joint), and tell what kind of load the parts can support. 2. Questions to ask the students: o How does the shape of the structure affect its strength? o Does it matter where you place the load when testing structures? o Why do you think our furniture is made the way it is? Could we substitute some of our tested objects for the chair legs to save money? Why or why not? Which objects might work as chair legs? How do you know these objects will work?	Students tour the school looking for examples of structures to share in class	

My favorite structure (drawing):	Name:
Uses:	Properties:

Structures Web

Find and draw or write examples for each box.



Performance Test

Investigate! Compression

Compression is a pushing force (or load) on a structure. We put *columns* to support compression in structures. Find out how the objects act under compression:

Object	Results
A	
B	
C	
D	
E	
F	
G	
H	

Investigate! Tension

Tension is a pulling force (or load) on a structure.

Find out how the objects act under tension:

Object	Results
A	
B	
C	
D	
E	
F	
G	
H	

Investigate! Bending

Bending is a force (or load) at one side of a structure that makes it curve. We put *beams* to support bending forces in structures.

Find out how the objects act under bending:

Object	Results
A	
B	
C	
D	
E	
F	
G	
H	

Investigate! Torsion

Torsion is a twisting or wringing force (or load) on a structure.

Find out how the objects act under torsion:

Object	Results
A	
B	
C	
D	
E	
F	
G	
H	

Object	Compression	Tension	Torsion	Bending
A				
B				
C				
D				
E				
F				