Design Technology in Engineering Education for English Learners: Project DTEEL

NSF DRK-12 # 1503428

University of Texas, Austin

Fourth Grade
Lesson Plans
Units 1-9

DTEEL Fourth Grade Lessons

Unit 1 (Materials):
The Materials Cycle

Concept
There is a cycle of production for the things we use every day. Energy is the cost of keeping the cycle going, and we can save energy by closing some of the loops.

Content objective
Students understand the production of some materials and become familiar with the Materials Cycle.

Language objectives
Discuss the main features of green re-cycling.
Interpret and discuss short readings on green design principles using comparative languge, e.g., *adjectives and conjunctions.*
Explain how raw materials are processed using logical connectors: *sequencing words- because, then, subsequently, consequently.*

Standards
- **NGSS**:
  - **3-LS4-4.** Evaluate a solution to a problem caused when the environment changes and how the types of plants and animals that live there change.
  - **3-ESS2-1.** Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.
- **TEKS:**
  - **1B** Students will make informed choices in the use and conservation of natural resources and reusing and recycling of materials.
  - **6A** Students will differentiate among forms of energy, including mechanical, sound, electrical, light, and
  - heat/thermal.
- **ELPS:**
  - **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]
  - **3D** Students will speak using grade-level content area vocabulary in context to internalize new English words and build academic language proficiency. [Application for Acquisition]

- **4G** Students will demonstrate comprehension of increasingly complex English by participating in shared reading, retelling or summarizing material, responding to questions, and taking notes commensurate with content area and grade-level needs.

Materials

- Chalk or 8 playground markers, such as traffic cones or softball bases
- Lesson handouts **4.1.1- 4.1.8**
- Realia for students to use in walking the Materials Cycle

Literature Connections

The Three Little Pigs: An Architectural Tale by Steven Guarnaccia

Day 1: Engage/Explore

Teacher Says/Does	Student Says/Does	Language Requirements
1. Ask student pairs to discuss for a few minutes what they know or have heard about life cycles. They may know about the life cycles of living things, seasons, and other examples. Discuss with them how anything that occurs over and over again in a pattern of returning to the beginning is a cycle. 2. Hold up or point to a classroom object that has been made by people, such as the overhead projector. Ask students if objects such as this might begin and end in a cycle of some sort. 3. Continue discussing the object and how it might have been made, while collecting the students' ideas about the source of manufactured items. 4. Help the students learn about the production cycle of a chosen raw material using visuals. You might trace the production of a popular toy to capture their interest. 5. Organize students into groups and ask them to select a life cycle to discuss and to illustrate, using handout **4.1.1**. 6. Have each group write about its material using the handout provided and then share the results with the rest of the class.	Students reflect, discuss, and share ideas based on what they know of life cycles Students use a graphic organizer to focus on one life cycle to analyze, to discuss, and to write about in groups before sharing their knowledge with the rest of the class	Cycle Production cycle Raw material

Day 2: Explore/Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. In whole group, show students the materials cycle with a green loop (**4.1.2**). Ask one or two students to describe what they see on the handout. 2. Organize an election among students to select one life cycle that will be analyzed using the materials cycle in the lesson handouts. 3. Trace the story of the selected item on the materials cycle. Ask the children what might happen to the sample object when it is no longer useful. Collect a few responses. Prompt students to talk about their selected material using sentence starters from handout **4.1.3**. 4. Using handout **4.1.4** as a guide, select students to read each of the eight sentences, and ask questions that will lead them to select the right choice of word in each case. 5. Organize students into five groups and distribute each a paragraph from handout **4.1.5** for students to read and discuss. Have each group share the main idea, one important detail, and one way in which this is important in their daily lives. 6. Have each individual student write up at least two sentences that reflect on green design based on the ideas discussed (see handout).	Students discuss a diagram illustrating the materials cycle and use sentence starters to talk about the life cycle of the material selected Students read and discuss sentences about green design Student groups read and analyze the paragraphs, identifying main ideas and sharing one aspect that is relevant in their lives Students read and analyze sentences related to green design Students individually construct sentences integrating ideas discussed	Production cycle Landfill Raw material Process material Dispose Recycle Fix, refill, reuse Employ sentence starters in handouts for students to use as part of oral discussions and for writing their reflections

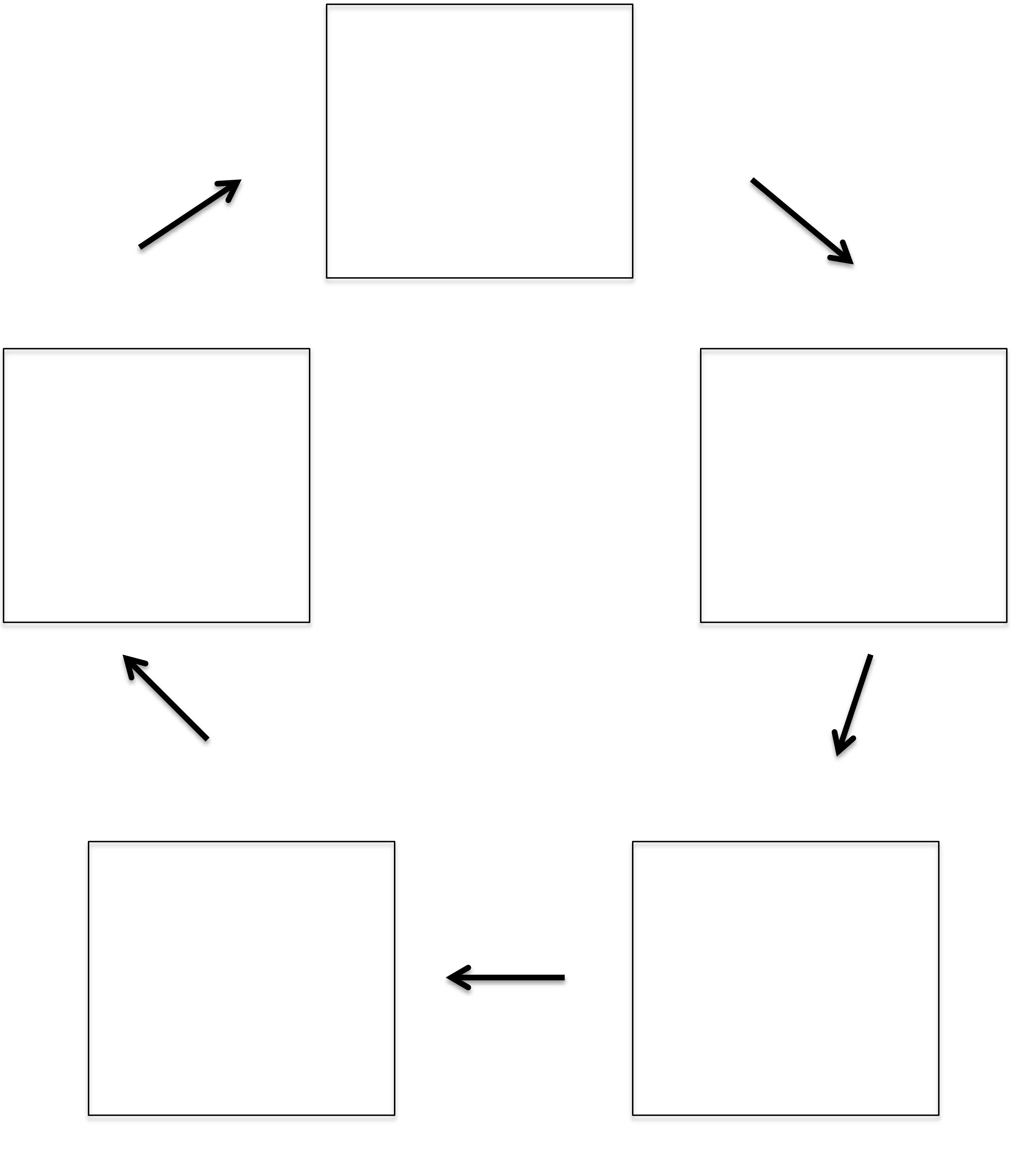
Day 3: Explore/Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. Remind students of materials cycle completed the previous day (**4.1.1**) and discuss key elements/processes. 2. Organize students in teams so that each team will play the part of a raw material and a product, using a slip cut from the Raw Materials Role Play handout (**4.1.6**). 3. Student groups discuss the cycle of each of their raw materials using the materials cycle. 4. When students get to the "USE" part of the cycle, they need to think about the material's end-of-life. Will they recycle? Will they fix? Will they reuse? How? Students should explain what they would do to prevent having to DISPOSE of their material. Whenever a team thinks of a new way to stay in the "green loop," everyone should cheer from the Earth. 5. Have one student from each team stand in the Earth section of the cycle. The rest of the students will watch the representative walk through the steps with the chosen raw material, while telling what the material is and how it is processed. 6. Questions to ask the students: o How is recycling helpful to the Earth? o Where do people make the biggest impact on the materials cycle? (Buying, creating demand for new things, or helping to recycle) 7. Organize students in pairs and have each choose another raw material and, using the materials cycle handout (**4.1.1**), analyze the effects of make each of the following three choices: dispose of the material in the Earth, such as a landfill or dump; recycle it into basic materials; or fix and reuse it. 8. Have the students use sentence starters to write about their materials and/or allow them to write freely about their material, as long as they refer to the materials cycle handout. 9. Have students present their reflections to the whole group.	Students use a handout to describe a materials cycle Students role play with different materials to examine each material's life cycle	Production cycle Landfill Raw material Process material Dispose Recycle Fix, refill, reuse

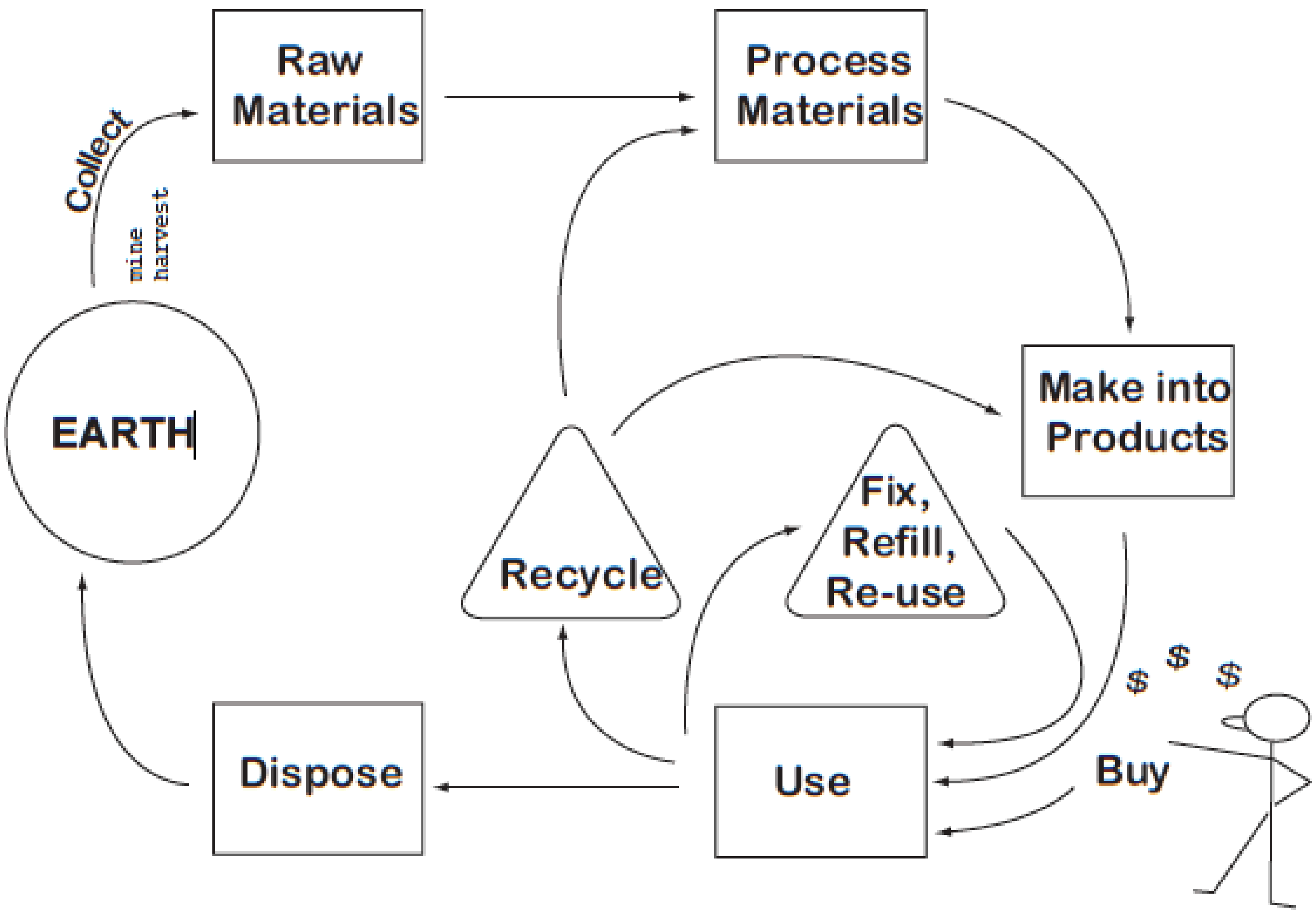
Day 4: Elaborate and Evaluate

Extensions into the Disciplines	Practical Extensions	Language Requirements
1. Have students review the graph on handout **4.1.7**, “Earth, We Have a Problem.” 2. In whole group, discuss the graph, and collect students' ideas about what the graph tells us. 3. Organize students into pairs and, have each analyze one statement from the bottom half of the handout, and share their understanding with the class. 4. Discuss with the students what Earth’s environmental problems are and the implications of these problems.	Students discuss a graph on garbage production and recycling	See handouts

Life Cycle



Total Materials Cycle with a Green Loop Resource



Sentence starters to write about the material chosen:

The raw material that we chose is ____.

We can buy it at ____.

It usually lasts ____.

It can be disposed by ____.

When we dispose of it, it becomes part of ____.

When we recycle it, it becomes part of ____.

It can/cannot be recycled because ____.

It can/cannot be fixed, refilled, and re-used because ______________________________________.

One difference between raw materials and processed materials is ___________________________.

In the following sentences, select one of the two words in parenthesis that would apply to green design.

1. Green design involves using (less/more) virgin or raw material.

2. We generate waste that will have a (small/big) impact on the environment.

3. We want to (prevent/allow) toxic waste from manufacture, recycling, and disposal.

4. We design products so their packaging (can/cannot) be recycled.

5. We design machines so they can be (assembled/disassembled) easily.

6. We use (less/more) material and energy to do the same work as original designs.

7. We use (few/ many) raw materials in manufacture that reach the DISPOSAL stage of the Materials Cycle.

8. We want to (decrease/increase) the time that products stay in use.

Group 1: Raw Materials

The Earth's resources include organic and inorganic matter that we harvest for production. These *raw materials* include mineral ores containing metals, such as iron, aluminum, nickel, copper, tin, gold, silver, zinc, mercury, and lead. Non-metallic minerals include sand, gravel, limestone, salts, and sulfur. Organic raw materials include fossil fuels (natural gas, coal, and petroleum) and plant materials, such as wood.

Group 2: Energy is the Bottom Line

The farther we take a raw material in the Materials Cycle, the more energy we use in its processing. We can call this energy use "solar dollars," which includes all the energy consumed since the raw materials were created. These solar dollars will include the energy involved in the creation of a mineral, the energy we use to find and transport materials, *and* the energy we need to train, feed, and transport the people involved in the process. Along every stage of processing, we consume solar dollars. However, we don't incorporate these "solar dollars" (the true cost) in the cost of the finished product.

Group 3: What consumers can do

Consumers who want to conserve energy will *reduce* their purchase of non-recyclable packaging and products, *re-use* packaging and products, and *recycle* organic and inorganic materials so that as few items as possible enter the DISPOSE phase of the Total Materials Cycle. The "green loop" of the Materials Cycle is the area in which we learn how to do just that.

Group 4: How engineers practice green design

Engineers want to make it easier for materials to avoid disposal, so they practice "green design." One way of practicing green design is to use recycled materials. An example is Dupont recycling milk jugs into park benches and padded envelopes. IBM recycles the housing on their computers into roofing tiles for McDonald's restaurants. Another way of practicing green design is to create packaging that can be refilled and recycled. For example, Proctor and Gamble Company makes many of their products in sturdy containers and sells refills, reducing their packaging needs by 80%. A third way of practicing green design is to consider end-of-life issues so there are as few steps as possible in taking a product apart for recycling, as when a product can be disassembled in seconds.

Group 5: Saving costs with Green Design

Engineers can save energy in processing and disposal, and, therefore, lower costs. For example, by practicing green design in auto manufacture, Chrysler Jeep [<removed /] saves $2 million per year on its garbage bill and eliminated 70% of landfill-bound trash. Whirlpool Company, in Germany, reduced its number of packaging materials from 20 to 4, which decreased their disposal costs by 50%.

Source: Fowler, Crawford, Wood & Jones (2000). Beginning Lessons in Engineering Design Level D Lessons. Green Design Learning Experience Background Information (p. 12)

Raw Materials Role Play

1. You are wood that is cut and then processed into pulp and then made into school paper.	2. You are wood that is cut and then processed and cut and then made into lumber.
3. You are bauxite, aluminum ore, and you are mined and then processed and then made into aluminum and then made into a soft drink can.	4. You are bauxite, aluminum ore, and you are mined and then processed into aluminum and then made into a ladder.
5. You are iron that is mined and then processed with carbon into steel and made into a can to hold beans.	6. You are iron that is mined and then processed with carbon into steel that is made into car bodies.
7. You are copper that is mined and then processed and made into electrical wire.	8. You are copper that is mined and then processed and then made into a cooking saucepan.
9. You are copper that is mined and processed with zinc to make brass and then is made into door hinges.	10. You are copper that is mined and processed with zinc to make brass that is made into a musical horn like a trumpet.
11. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into high-density polyethylene (HDPE) and then made into milk jugs. (# 2 plastic container code)	12. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into low-density polyethylene (LDPE) and then made into plastic bags. (# 4 plastic container code)
13. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into polypropylene (PP) and then made into chair seats. (# 5 plastic container code)	14. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into polyvinyl chloride (PVC) and then made into plumbing pipes. (#3 plastic container code)

15. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into polystyrene and then made into plastic foam meat trays.
(# 6 plastic container code)

16. You are the oil (petroleum) gas called ethylene that is processed into polyethylene and then processed into polyethylene terephthalate (PET) and then made into a green soft drink bottle. (# 1 plastic container code)

17. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into nylon and then made into toothbrush bristles.

18. You are the oil (petroleum) gas called ethylene that is processed into polyethylene and then processed into phenol formaldehyde and then made into dark-colored, heat-resistant saucepan handles.

19. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into urea formaldehyde and then made into hard, colored bottle tops.

20. You are the oil (petroleum) gas called ethylene that is processed into polyethylene and then processed into melamine formaldehyde and then made into unbreakable plates and cups.

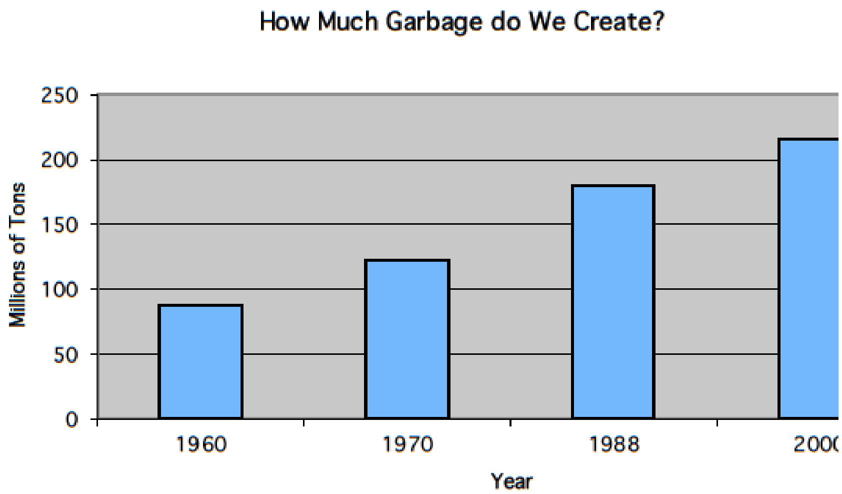
21. You are the oil (petroleum) gas called ethylene that is collected and then processed into polyethylene and then processed into polyester resin and mixed with glass to make fiberglass and then made into a canoe.

22. You are the oil (petroleum) gas called ethylene that is processed into polyethylene and then processed into melamine formaldehyde and then made into cutting boards for the kitchen.

23. You are rock that is quarried and processed into sand and gravel and then into concrete and then made into a cinder block for use in making a building.

24. You are limestone rock that is quarried and processed into blocks and made into a wall.

Earth, We Have A Problem, adapted (Handout)



In America, we cut down 1600 trees every minute to make paper.	It takes 90% less energy to recycle an aluminum can than to make a new one.
The energy saved by recycling one glass bottle, instead of making a new one, would power a light bulb for four hours.	Every ton of paper recycled can save 17 trees.
For us, this means that _______________ ___________________________________.	One problem we see is ______________ ___________________________________.

Explore/Explain

Green design individual reflection

I think the most important idea in green design is ____.

What I like the most about green design is ____.

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 ______.

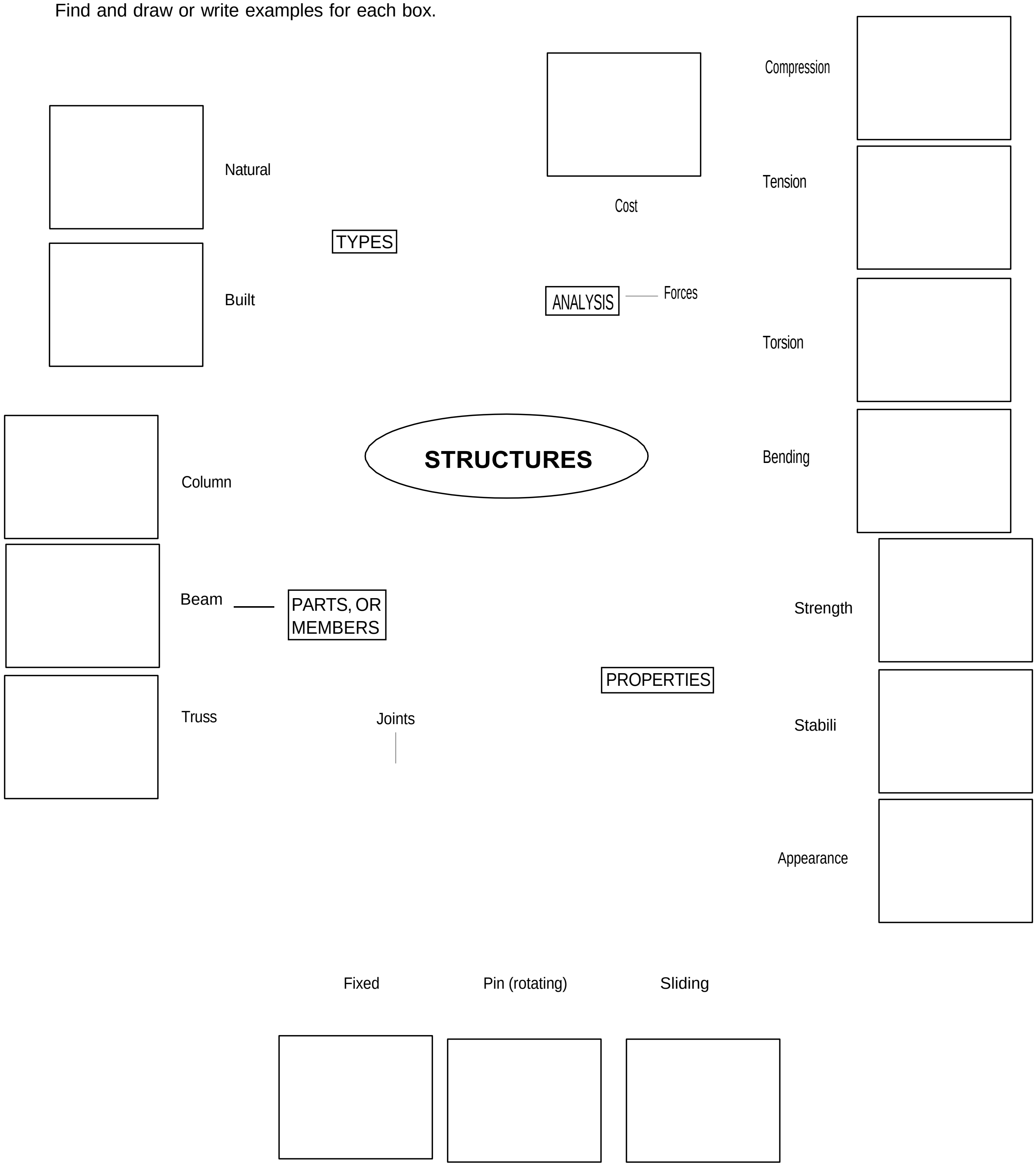
Day 4: Elaborate and Evaluate

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				

Unit 3 Structures:
Testing Constructions and Techniques

Concept

The way that we join parts of structures depends upon the materials we are joining and upon the loads the joints and the members will experience.

Content objective

Explore ways to make and join structural members; then create an information piece on construction techniques to present at a class symposium.

Language objectives

Orally describe various materials using target vocabulary.
Orally describe design characteristics *in detail* and group investigations using sequential language (*first, second, then, ultimately)*.

Standards

- **NGSS**:
  - **3-5 ETS 1.** Define a simple design problem, including criteria for success and constraints on materials, time, or cost.
  - **3-5-ETS1-2.** Generate and compare multiple solutions based on criteria and constraints of the problem.
  - **3-5-ETS1-3.** Plan and carry out fair tests that control for variables and identify failure points to improve a model.
- **TEKS**:
  - **3A** Students will analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing.
  - **3D** Students will connect grade-level appropriate science concepts with the history of science, science careers, and contributions of scientists.
  - **4A** Students will collect, record, and analyze information using tools.
  - **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]
  - **2F** Students will listen to and derive meaning from a variety of media, such as audio tape, video, DVD, and CD ROM to build and reinforce concept and language attainment [Listening Across Contexts]
  - **3H** Students will narrate, describe, and explain with increasing specificity and detail as more English is acquired.

Materials

Set up activity areas as follows:

- Use white paper, woodcraft sticks, drinking straws, string, pencils, or thin dowels (for rolling paper).
- Use low-temperature glue guns and sticks, white glue, staplers, transparent tape, and paper clips.
- Use weights, such as dictionaries, encyclopedias, bricks, or cinder blocks.
- Lesson handouts **4.3.1- 4.3.2**

Literature Connections

Twenty-One Elephants & Still Standing by April Jonew Prince

Day 1: Review[1] Engage/Explore

Teacher Says/Does	Student Says/Does	Language Requirements
1. Have students watch part of the National Geographic Megastructures documentary on the Golden Gate Bridge: https://www.youtube.com/watch?v=LmqWAz3OYlA 2. Ask students their opinion on what makes the bridge so strong, where compression and tension are present, and other aspects of the bridge and the design. Allow students to freely share their reactions. 3. Suggest to the children that they form construction company teams. Each company of four or fewer students will eventually build a bridge, but for now students will explore some construction techniques that will improve their bridge-building skills. 4. Write “Properties of Materials” on a chart and have students give you some examples of properties that they know (bendability, durability, and strength). Add "compression" and "tension" to the list. Have students volunteer the meanings they think apply to these property words. 5. Have students form teams to analyze whether or not a soft ball, clay, crackers, marbles, the floor of a house, and a plastic jug can be compressed or tensed (see handout **4.3.1**)	Students watch and analyze a documentary and share ideas Students share what they know about the properties of common materials	Compression Tension Bridge design Bendability Durability Strength

[1] The contents of this review are from lesson 1, Level C.

Day 2: Explore/Explain

<table>
<tr><th>Teacher Says/Does</th><th>Student Says/Does</th><th>Language Requirements</th></tr>
<tr><td>1. Introduce the concepts of columns and beams as part of buildings. Discuss the following questions:
• Can you make a paper column that will hold a book?
• Is a column that is made of straws strong under compression?
• How can we build columns that are strong?
• Can you make a paper beam that will hold a book?
• Is a beam that is made of straws strong under bending forces?
2. Point out the stations and materials.
3. Form teams and have student teams look at Activity A-Making Strong Columns and Beams and Activity B-Finding Best Ways to Connect (in handout 4.3.2) for directions.
4. Students are to find the best way to make columns and beams and join them. Then, they will test their connections with loads.
5. Let students begin work.
6. When the teams have finished exploring and have helped clean up, gather all students for a symposium; a sharing of research.</td><td>Students discuss columns and beams as part of buildings

Students investigate how to make columns and beams and join them. Students write the results of their investigations (see handouts for Activities A and B)

Students share the results of their investigations</td><td>Columns
Beams</td></tr>
</table>

Day 3: Elaborate and Evaluate

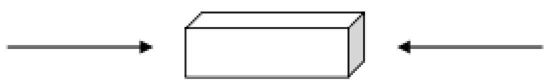
Teacher Says/Does	Student Says/Does	Language Requirements
1. Each team should summarize their results in a booklet or video called "Construction Tips," and present it to the class. 2. After all students have shared in this symposium, ask the following questions: • How many chances do you think a builder gets to make a bridge? Why only one chance? (It is probably too expensive in time and money to do over again!) • What does a bridge builder need to know before construction begins? (All about materials and joints) 3. What was some construction ideas you tried that did NOT work? This will save your classmates some problems and time. Display the booklets, student results, and some samples in a Design Gallery.	Students share their results as part of a symposium, and reflect on their work.	

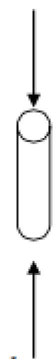
	What can be compressed (pushed in)?	What can be tensed (pulled apart)?
Soft ball		
Clay		
Crackers		
Marbles		
The floor of a house		
Plastic milk jug		

Activity A Making Strong Columns and Beams

Use the materials you see to make some **columns**. Remember, a column must be strong in *compression*.

- Can you make a paper column that will hold a book?
- Is a column that is made of straws strong under compression?
- What other kinds of columns can you make?

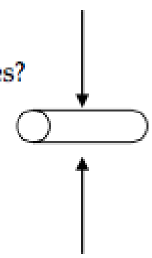


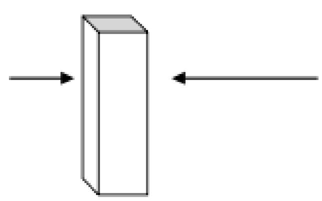


COMPRESSION
FORCE

Now use the materials you see to make some beams. Remember, a beam must be strong under *bending* forces.

- Can you make a paper beam that will hold a book?
- Is a beam that is made of straws strong under bending forces?
- What other kinds of beams can you make?





BENDING
FORCE

Make some extra samples for Activities B, C, and D.

Activity B Finding Best Ways to Connect

Use the connecting materials to join your columns and beams.

What works best to join materials together?

The Joining Chart

Write in the name of the best joining material or method:

	PAPER	WOOD	STRING	STRAW
PAPER				
WOOD				
STRING				
STRAW				

Unit 4 (Mechanisms):
Rotary Motion: Exploring with Gears

Concept
Rotary motion is movement in a circular direction; rotary motion can be transmitted through a system with gears.

Content objective
Explore how gears work in various combinations to change direction and size of motion.

Language objectives
Students will be able to orally describe some characteristics of gears *using adjectives*.

Standards

- **NGSS:**
  - **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation that people want to change to define a problem that can be solved with a new or improved object or tool.
- **TEKS**:
  - **6A** Students will differentiate among forms of energy, including mechanical, sound, electrical, light, and heat/thermal.
  - **6D** Students will test the effect of force on an object such as a push or a pull, gravity, friction, or magnetism.

ELPS:

- **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]
- **1D** Students will speak using learning strategies, such as requesting assistance, employing nonverbal cues, using synonyms and circumlocution (conveying ideas by defining or describing when exact English words are not known). [Making Meaning]
- **2F** Students will listen to and derive meaning from a variety of media, such as audiotape, video, DVD, and CD ROM to build and reinforce concept and language attainment. [Listening Across Contexts]
- **2I** Students will demonstrate listening comprehension of increasingly complex spoken English by following directions, retelling or summarizing spoken messages, responding to questions and requests, collaborating with peers, and taking notes commensurate with content and grade-level needs. [Demonstrate LC in Context]

Materials:
- Purchased plastic gear systems
- Gear picture cutouts
- Lesson handouts **4.4.1- 4.4.2**

Literature Connections
Gears in My World by Joanne Randolph

Day 1: Engage/Explore:

Teacher Says/Does	Student Says/Does	Language Requirements
1. Start a discussion about gears. Ask the students: a. Does a bike have gears? b. Do you know examples of gears used at home (e.g., manual egg beaters	Students share what they know about gears	Gear Gear teeth
2. Show students the gear pictures in handout **4.4.1**, and/or the following animations, have them pair share, and then share out with the rest of the class: • http://bestanimations.com/Science/Gears/silver-two-gear-cogs-animation-7.gif • https://upload.wikimedia.org/wikipedia/commons/2/22/Spur_gears_animation.gif • https://upload.wikimedia.org/wikipedia/commons/c/c3/Worm_Gear.gif	Students do a pair share to discuss gear pictures and animations	
3. Give each team of students a set of gears and ask them to color one tooth on each gear with a marker for a reference point (if gears are not already so marked). Ask students to count the number of teeth on the small, medium, and large gears and record the results on paper.		A (small/medium/large) gear has _____ teeth.
4. Ask students to predict how many turns of the small gear it will take to make the large gear turn one time. If possible, have them use a pegboard or gearboxes to test their prediction.	Students make predictions using plastic gears	________turns of the small gear are needed to make the large gear turn one time.

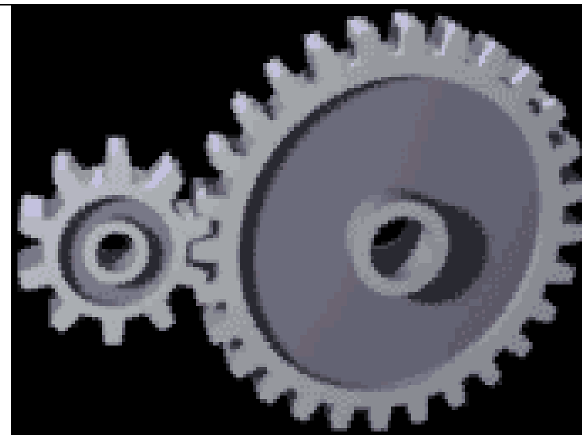
Day 2: Explore/Explain

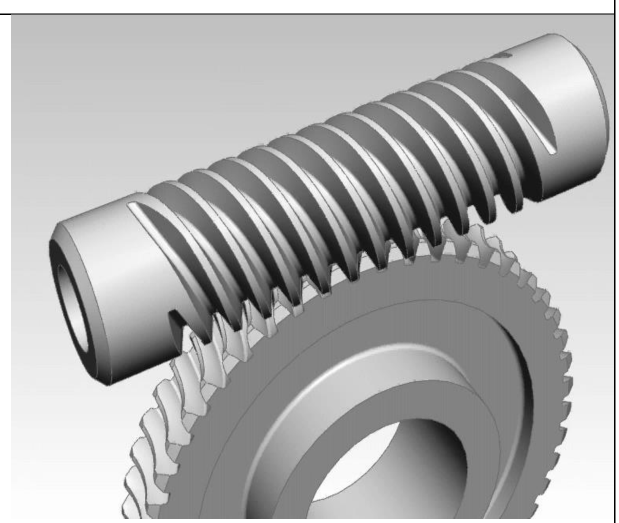
Teacher Says/Does	Student Says/Does	Language Requirements
1. Show students the Black Box System in handout **4.4.2**, reminding them of basic ideas behind this model. 2. Form students into groups so that each is assigned one of the three Black Box Systems in the handout: • one where one gear turns clockwise and the output is another gear turning clockwise • one where the input is one gear making turns clockwise and the output is the other gear turning counter-clockwise • one where the input is 3 turns of a big gear and the output is a little gear making 9 turns 3. Give teams a few minutes to explain what they are going to do and to resolve any introductory questions. 4. Let the teams work with the gears to try to devise systems that will create each model, using their gears and the gearboxes. 5. Ask each team to share their results and record briefly what they have found. Ask the students to make a rule about gear movements (adjacent or touching gears turn opposite directions).	Students talk and discuss with their teammates Students build a system using black box thinking	Adjacent gears Touching gears

Day 3: Elaborate and Evaluate

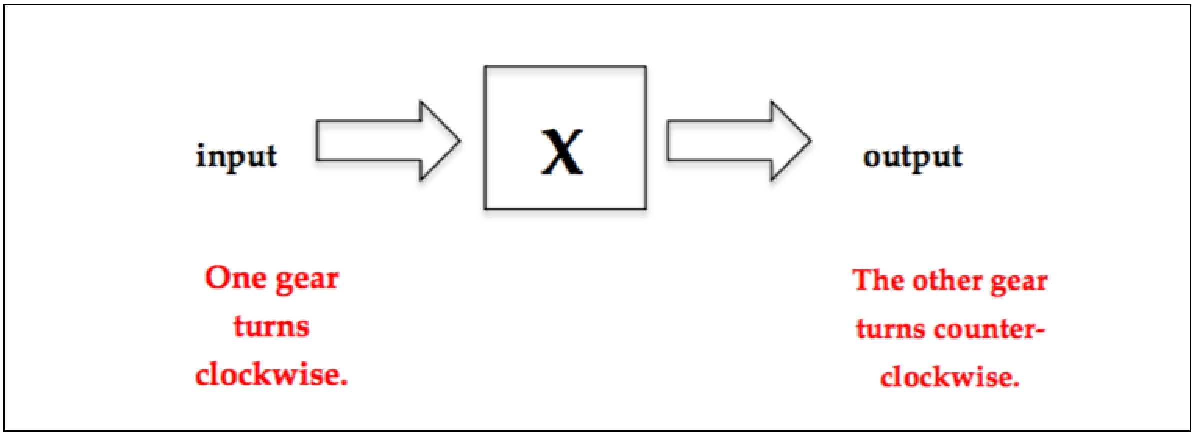
Extensions into the Disciplines	Student Says/Does	Language Requirements
Challenge each team to make a “mystery system” of gears, using a cover or a piece of paper to hide all but their input crank and output gear movement. When teams present their puzzle to the class, the others should use the gear picture cut-outs to infer the gears and their placement inside the system.	Students present and discuss their puzzles with their classmates	Input crank Output gear

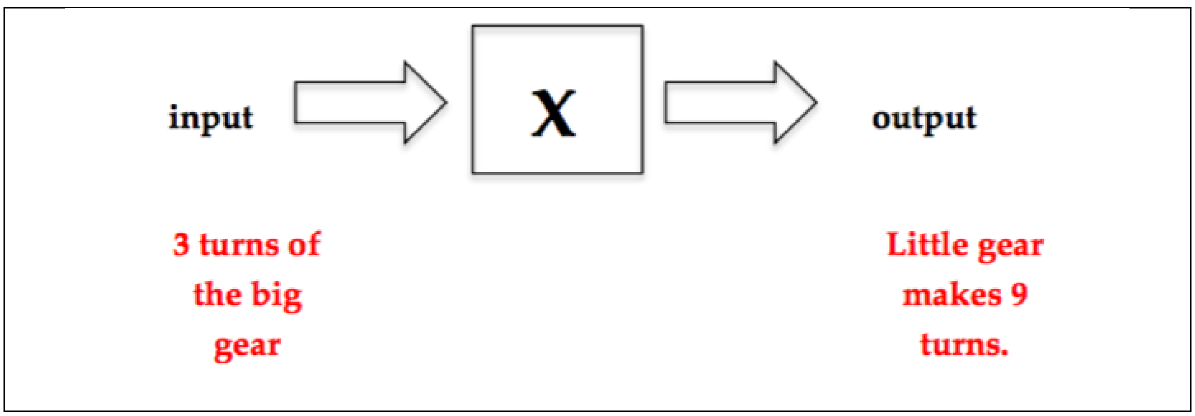
Engage/Explore

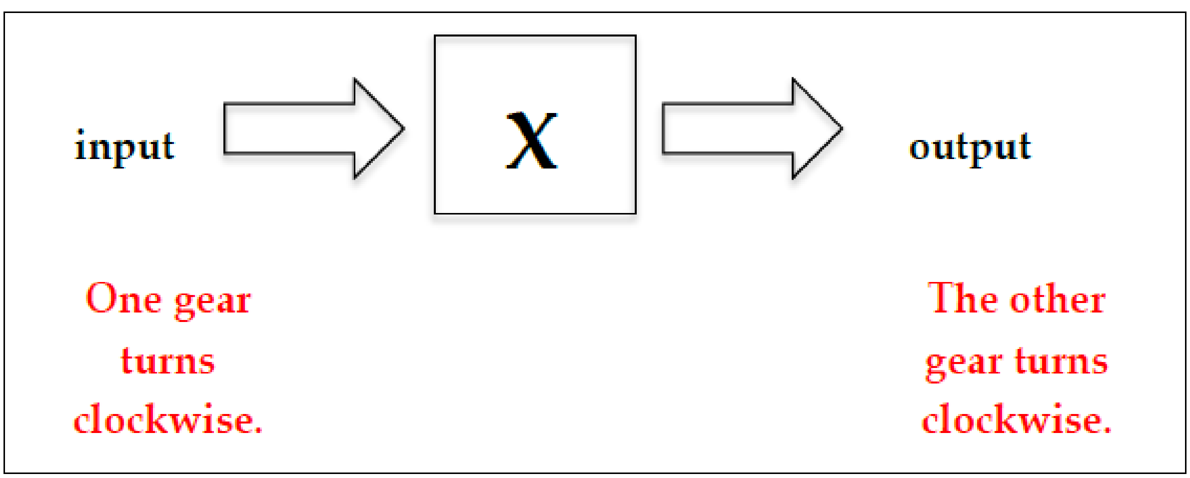




Black Box Systems







Unit 5 (Mechanisms):
More Rotary Motion: Exploring with Pulleys

Concept
Pulleys change direction of rotation; pulleys in a series increase power to do work.

Content objective
Explore how pulleys work to change direction of motion and increase power in lifting.

Language objectives
Make black box thinking predictions using the *conditional tense* and the structure, "*If…, then*".
Orally discuss the characteristics of pulleys using *descriptive vocabulary*.

Standards

- **NGSS**:
  - **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a problem that can be solved with a new or improved object or tool.
  - **K-2-ETS1-3.** Analyze data from testing two objects designed to solve the same problem in order to compare the strengths and weaknesses of each.
- **TEKS Science**:
  - **5A** Students will measure, compare, and contrast physical properties of matter, including size, mass, volume,
  - states (solid, liquid, gas), temperature, magnetism, and the ability to sink or float.
  - **6A** Students will differentiate among forms of energy, including mechanical, sound, electrical, light, and heat/thermal.
  - **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]
  - **3E** Students will share information in cooperative learning interactions. [Communicative Competence]
  - **3H** Students will narrate, describe, and explain with increasing specificity and detail as more English is acquired.

Materials

- Pulleys, rope or string, spring scales
- Load to lift (e.g., a bucket of blocks)
- Stand or location to hang pulleys (e.g., monkey bars, hook hanging from ceiling, swing set, chart tablet stand, coat rack)
- Lesson Handouts **4.5.1- 4.5.3**

Literature Connections

How to Lift a Lion by Robert E. Wells

Day 1: Engage/Explore

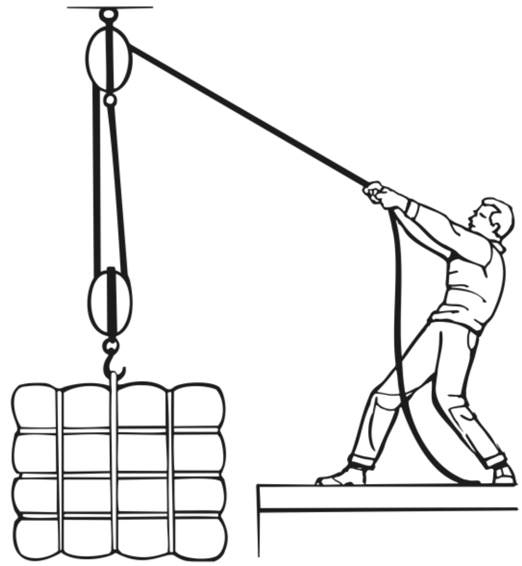
Teacher Says/Does	Student Says/Does	Language Requirements
1. Take the students outside and look at the flag on your school flagpole. Ask the students to talk about how the flag is hoisted up so high by such short people as children. Give them time to talk about how it might be done. Perhaps someone can lower and raise the flag for the children to see. Do the children know the name of the mechanism that lets you pull down on a rope and make something go up? 2. Form groups of students and give each group one of the pictures from handout **4.5.1.** Have each group discuss what it sees in the assigned picture, and have each identify examples of something similar that the students have seen in their lives. Have each group share one sentence describing the assigned picture, and one sentence about something similar the students have seen in their lives. 3. Tell the students that a pulley is a wheel that changes the direction of movement; pulleys are often used to lift objects. Demonstrate by hooking a pulley up to a stand, then passing a cord over it and through the groove in its edge. Hook a load, such as a bucket of blocks, on one end of the rope and ask a student to pull down on the other end. Ask students to discuss the following question in pair-share: How does the pulley change the direction of movement? 4. Place a loop in the rope or string and place the hook of a spring scale in the loop; raise the bucket up by pulling on the top of the spring scale. You can see on the scale roughly the force it takes to raise the bucket of blocks. 5. Ask the students to help you draw a Black Box Model for what is happening (see handout **4.5.2**).	Students discuss pictures that illustrate pulleys and share their prior knowledge and experiences with pulleys Students apply black-box modeling thinking to pulleys	Pulley Black-box modeling

Day 2: Explore/Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. Have students discuss in pairs or in groups how simple pulleys work based on previous activities or based on using the figure contained in handout **4.5.2** 2. Ask students if they can find a way that a series of pulleys can be used to do more work than one pulley. One way is to run the rope through a second pulley that hangs on a loop of the rope. Try this and use the spring scale with the same load. What happens? 3. Using the figures in the handout, invite students to talk about the possible advantages of using more than one pulley. Discuss the concept of mechanical advantage. 4. Do the students know examples of how pulleys are used to lift very heavy objects? (A block and tackle is a set of pulleys that can be used to lift an engine from a car.) 5. Let teams of students work with sets of pulleys, the spring scale, and loads to lift. Have students record the force (as measured by the spring scales) for each load lifted. Try various combinations; then write the data in a chart. 6. If students add one more pulley into the system, there are more sections of rope sharing the load. Students may see a pattern of mechanical advantage provided by an increased number of rope sections and write it in the data table. NOTE: The friction in the axle of the pulley across the surface of the groove may affect readings of force on the spring scale.	Students experiment with simple pulleys; discuss visuals of simple pulleys, and discuss the mechanical advantage of a system of pulleys	Single pulley Clamp Spring scale Mechanical Advantage In a simple pulley, the clamp serves to____________. The spring scale is attached at the end of the loop in order to____________.

Day 3: Elaborate and Evaluate

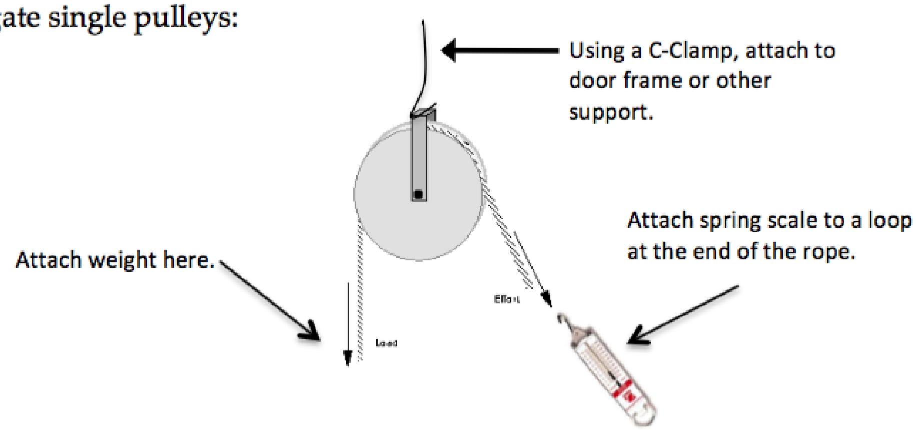
Extensions into the Disciplines	Student Says/Does	Language Requirements
Evaluate 1. Have students complete the paragraph on handout **4.5.3** using the words in the word bank. 2. Allow them to form groups to create a presentation in which they respond to the following questions using their own words: • What are pulleys? • What do pulleys do? • What are some advantages of a pulley? • What are some examples of pulleys?	Students summarize their learning about pulleys by creating a presentation	Pulleys



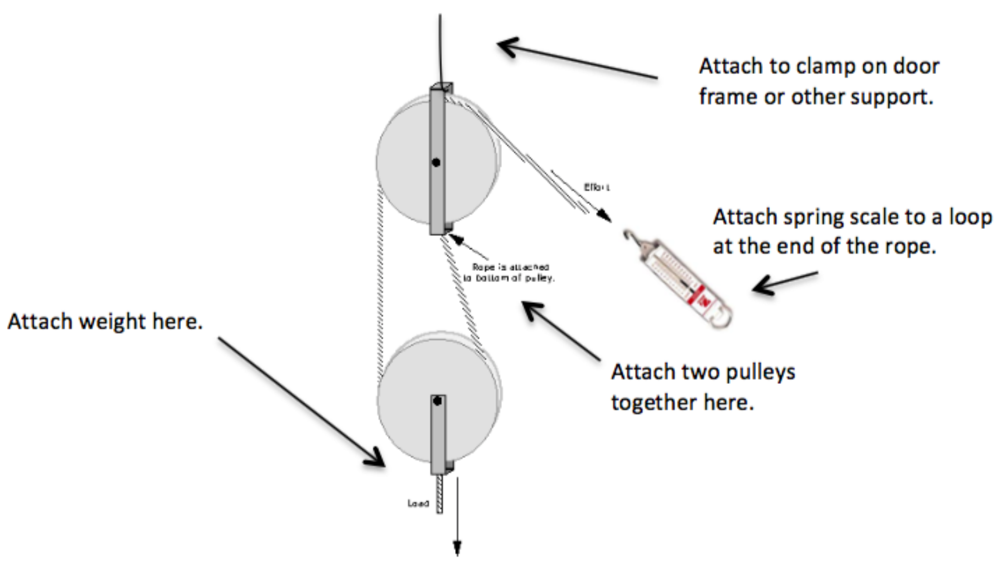
Black Box Model

input	**->**	**X**	**->**	**output**
pull down	->		->	bucket goes up

Investigate single pulleys:



Investigate mechanical advantage with pulleys:



change	raising a flag on a flagpole
Systems of pulleys	wheel-and-axle mechanisms
can reduce	engines

Complete the paragraph below by choosing the appropriate word from the following options.

Pulleys are ______________________________with grooves that guide a rope or a belt. Pulleys _______________________________ the direction of effort, and, if used in sets, _________________________________the effort needed to do work. Pulleys are used in many applications, such as ______________________________, lifting a garage door, and lowering a bucket into a well. _____________________________ in a block and tackle can lift ___________________________ out of cars.

Questions to answer in groups:

- What are pulleys?
- What do pulleys do?
- What is the advantage of a pulley?
- What are some examples of pulleys?

Unit 6 (Work & Energy)
Hydraulics: Exploring Water Power

Concept
Water can be used to send power through a system of mechanisms**.**

Content objective
Students explore transmission of power with water using syringes and tubing, waterwheels, and other turbines.

Language objective
Describe experiments with water systems *using target vocabulary*.

Standards

- **NGSS:**
    - **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-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses (if the comparison of waterwheels is conducted).
- **TEKS:**
    - **1A** Students will demonstrate safe practices and use safety equipment.
    - **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.
    - **2D** Students will analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.
    - **3A** Students will analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing.
    - **3C** Students will represent the natural world using models.
    - **4A** Students will collect, record, and analyze information using tools.
    - **6A** Students will differentiate among forms of energy, including mechanical, sound, electrical, light, and heat/thermal.

- **ELPS**:
    - **3D** Students will speak using grade-level content area vocabulary in context to internalize new English words and build academic language proficiency. [Application for Acquisition]
    - **3E** Students will share information in cooperative learning interactions. [Communicative Competence]

Materials:

- Syringes and plastic tubing (syringes are available from veterinary supplies)
- 50 1 oz. plastic cups (medicine cups/soufflé cups) all construction and craft materials
- Quart-size zip-sealing plastic bags
- Paper towels
- Lesson handouts **4.6.1- 4.6.3**

Literature Connections

Hamish McHaggis: The Wonderful Waterwheel by Linda Strachan

Day 1: Engage/Explore

Teacher Says/Does	Student Says/Does	Language Requirements
1. Form student pairs or groups and have each pair or group analyze and then discuss with the class one of the figures in handout **4.6.1**. 2. Ask students to talk about things we know that are full of water and whether or not they can be squeezed and made smaller (such as water balloons, water beds, or hot water bottles). 3. Put some water in a zip-lock bag and hold it up for the children to see. 4. Ask students to describe some properties of the water in the bag. (It is clear, it moves around.) 5. Ask students if they think the bag of water can be compressed and made smaller. 6. Let one student try to do this. 7. Remind the students about the mechanisms they have learned that send power through a system (gears, pulleys, levers), and ask if anyone can think of ways that water can send power through a system. (Students might say that moving water can move things.)	Students share experiences and interpretations with everyday objects or systems that use water Water can send power through a system by _____.	Syringes Tubing Gears Pulleys Levers Hydraulics

Day 2: Explore/Explain

<table>
<tr><th>Teacher Says/Does</th><th>Student Says/Does</th><th>Language Requirements</th></tr>
<tr><td>

Assign student pairs, and give each a plastic “science syringe” and a few paper towels. Point out to the students that the syringe does not contain a needle and is made especially for measuring and dispensing liquids. Tell them that they should never touch syringes they find, especially any with needles on them. Students should only use “science syringes” at school.
Pass out a 1-ounce plastic cup of water to each group, and ask them to find a way to put at least half of their water into their syringe. After a few minutes, let some share their methods (the easiest way is to pull back on the plunger and draw water up into the syringe).
Discuss why it is difficult to just pour water into the syringe. (The opening is small; there is air inside keeping the water from completely filling it.)
As they push the water out of their syringes back into their cups, ask students to describe “water power” (The force of water can push things; the harder, or more quickly, the water is pushed out, the more power the water can have.)
Have the teams try these activities to explore with the syringes:

Fill the syringe with water, and have a partner cover the open end with a finger. Try to push the plunger down. What happens? (When the end is blocked, the water can't get out, and the plunger won't move.) Try to pull the plunger up. What happens? (It is difficult to pull because the end is blocked and the water inside can't stretch to fill a bigger space.)
Have teams take a length (about 3’ long) of plastic tubing. Push it onto the end of one syringe, then draw some water into the syringe through the tubing. Fill another syringe with water and connect the other end of the water-filled plastic tubing to the new syringe. Now

</td><td>Students explore methods to put water into a syringe, investigate some properties of a water-filled system of syringes, and discover some characteristics of water power

When I push down on the plunger, the water ____ by/because _____.

When I pull the plunger, the water _____ by/because _____.</td><td>Dispensing
Plunger</td></tr>
</table>

Teacher Says/Does	Student Says/Does	Language Requirements
you have a water-filled system of syringes and plastic tubing. Have the teams find out: What happens if one person pushes down on the syringe plunger? (The other syringe plunger pushes out.) Why does this happen? [Is this 8 a bullet?] o Using the same system of connected syringes, find out what happens if one person pulls up on the plunger. (The other plunger gets drawn in.) Why does this happen? 6. Write on the chart (handout **4.6.2**) "Examples of Water Power," and ask students to make some generalizations about work that water can do, as shown by their syringe systems. Students may say water can push and pull, for example.		

Day 3: Explore/ Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. Ask the students to think of some ways the pushing power of water could be used as a mechanism to make a model move. 2. Can any of the students describe other ways water can carry force and do work? Draw a simple waterwheel (see handout **4.6.3**) on the board, and ask the students how a model of such a device might be made. Have a student trace the flow of power through the waterwheel drawing as water turns the wheel. 3. Teams may like to make simple waterwheels out of plastic bottles and other craft materials. Under the faucet, find out how certain amounts of, or pressures of water, can create different numbers of turns on different waterwheels. Compare the waterwheels for efficiency and input/output motion.	Students experiment with water wheels	Waterwheels Input/output motion

Elaborate/Evaluate

Teacher Says/Does	Student Says/Does	Language Requirements
1. **Have students watch and make comments on the following video, How the Bicycle Pump Works**: http://www.ency123.com/2013/08/how-bicycle-pump-works.html 2. Have student teams select one topic discussed in the lesson to summarize what they investigated, what they did as part of the investigation, their results, and one favorite or important idea.	Students summarize and describe their explorations with water power with the rest of the class	Waterwheels Input/output motion

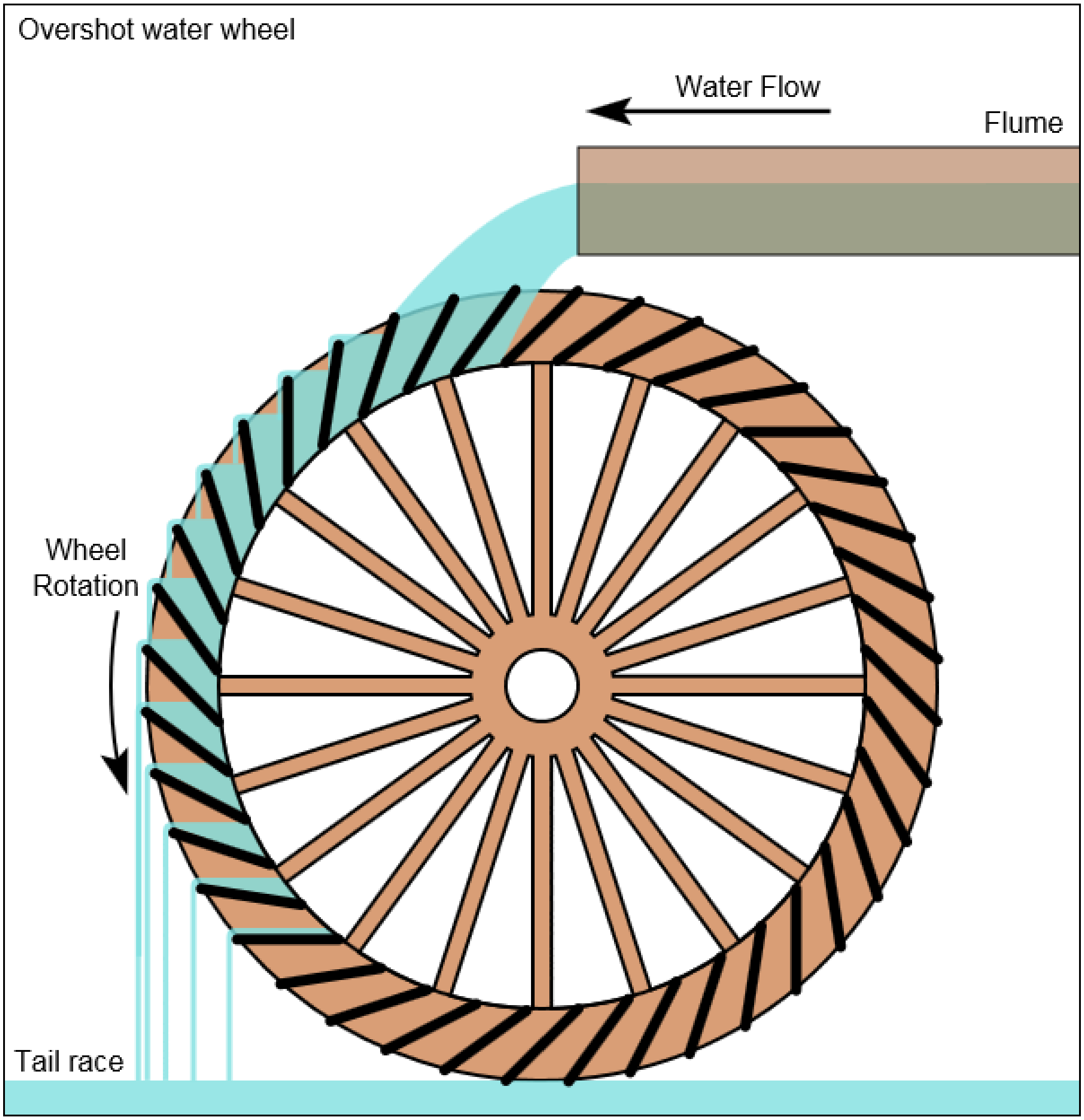
	
	
	

What we investigated:

Techniques we used:

Our results:

Our powerful idea:


Overshot water wheel
Water Flow
Flume
Wheel
Rotation
Tail race

Unit 7 (Work & Energy):
Pneumatics: Exploring Air Power

Concept
Air can be used to transmit power through a system.

Content objective
Teams explore transmission of force with air by using and analyzing syringes and tubing. They also discuss valves as mechanisms to control flow of water and air in systems.

Language objective
Students use target vocabulary to describe experiments with systems that transmit power using air.

Standards

- **NGSS:**
  - **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a problem that can be solved with a new or improved object or tool.
  - **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses (if the comparison of waterwheels is conducted).

- **TEKS:**
  - **1A** Students will demonstrate safe practices and use safety equipment.
  - **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.
  - **2D** Students will analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured.
  - **3A** Students will analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing.
  - **3C** Students will represent the natural world using models.
  - **4A** Students will collect, record, and analyze information using tools.

- **6A** Students will differentiate among forms of energy, including mechanical, sound, electrical, light, and heat/thermal.

- **ELPS**:
  - **3D** Students will speak using grade-level content area vocabulary in context to internalize new English words and build academic language proficiency. [Application for Acquisition]
  - **3E** Students will share information in cooperative learning interactions. [Communicative Competence]

Materials:
- A zip-seal plastic bag
- Bicycle pump
- Balloons
- Balloon plugs (from a party supply store)
- Plastic syringes
- 3' pieces of plastic tubing to distribute to each group
- Construction materials
- Lesson handouts **4.7.1- 4.7.4**

Literature Connections
Wind and Water at Work: A Book About Change by Thomas F. Sheehan

Day 1: Engage/Explore:

Teacher Says/Does	Student Says/Does	Language Requirements
1. Give student groups one of the pictures from handout **4.7.1** to interpret and discuss. 2. Fill a zip-sealed bag with air by blowing into it and seal it. Hold it up for the children to see. Ask them to describe some properties of the air in the bag (It is clear, it moves around.) Have students form pairs to discuss and share answers to the following questions: How did the air get into the bag? Can the air be compressed and made smaller? 3. Let one student try to do this. Ask student pairs to talk about things we know that are full of air and whether or not they can be squeezed and made smaller (balloons, air mattresses, beds, etc.). Students may note that the bag can be squeezed and compressed to a greater degree than could a bag of water. 4. Remind the students about the mechanisms they have learned about that send power through a system (gears, pulleys, levers). 5. Ask students to think of ways that air can send power through a system. 6. Give each student pair a plastic syringe, and ask them to find a way to put air into their syringe. Let some share their methods. (The easiest way is to pull back on the plunger and draw air up into the syringe.) 7. Ask pairs to describe “air power” as they push the air out of their syringes. (The force of air can push things; the harder, or more quickly, the air is pushed out, the more power the air can have.) 8. Have student pairs or groups complete the graphic organizer (**4.7.2**) on the different systems that generate power.	Students explore the properties of air Students connect prior knowledge of gears, pulleys, and levers with systems that get power from air Students describe the concept of "air power" Air can send power through a system by _____.	Gear Pulleys Levers Air power

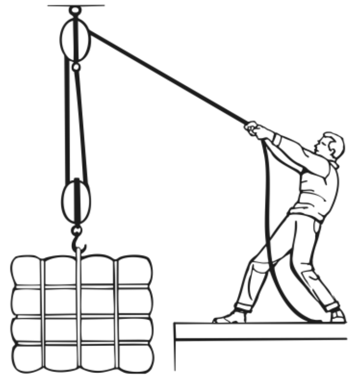
Day 2: Explore/Explain

Teacher Says/Does	Student Says/Does	Language Requirements
1. Have student teams try the following activities to explore with the syringes: 2. Fill a syringe with air and have a partner cover the open end with a finger. Try to push the plunger down. What happens? (When the end is blocked, the air can't get out and the plunger won't move much.) Try to pull the plunger out. What happens? (It is difficult to pull out because the end is blocked and the air inside can't stretch to fill a bigger space.) 3. As a whole group, discuss the way the air behaves when it is compressed compared to the way compressed water behaved in the syringe. Is there a difference in the way the two fluids respond to compression? (Air can be compressed measurably; water cannot.) 4. Have teams take a 3' length of plastic tubing. Push it onto the end of one syringe and then draw some air into the syringe through the tubing. Fill another syringe with air and connect to the other end of the same piece of plastic tubing. Now you have an air-filled system of two syringes attached with plastic tubing. Have the teams find out what happens if one person pushes down on the syringe plunger? (The other syringe plunger pushes out.) Why does this happen? 5. What happens if one person pulls out on that person's plunger? (The other plunger gets pushed in.) Why does this happen? 6. Write on the chart "Examples of Air Power" (**4.7.4**) and ask that students make some generalizations about work that air can do. They may mention that air can push and pull a syringe plunger and other things. 7. Ask the students to think of some ways the pushing power of air could be used as power to make a model move.	Students experiment with air-filled and water-filled syringes. When I push down on the plunger, the air ____ because _____. When I pull the plunger, the air _____ because _____.	Plunger Compressed air

Day 3: Elaborate and Evaluate

Teacher Says/Does	Student Says/Does	Language Requirements
Elaborate • Ask student groups to describe other ways air can push, pull, and do other work? Can groups think of mechanisms that work on the principle of air creating rotary motion? (Examples might include windmills or pinwheels.) If students made sailboats at an activity center, ask them to tell what they found about the sizes and shapes of sails that worked best. Why did certain sails work better? • Show the students the bicycle pump and ask someone to demonstrate how it works. You may be able to take the pump apart and have students locate the valve; a mechanism that permits a one-way flow of air in the pump. Explore the pump with these questions: o What happens when you push down on the pump handle? (Air comes out of the end of the hose.) o What happens when you pull up on the handle? (It is hard to pull up.) o Does air go back from the tire or ball into the end of the hose? (No) Why doesn't the air go back in? (There is a valve on the tire or ball that keeps air going one way only.) **Evaluate** • Have student pairs complete the graphic organizer (**4.7.3**).		

Systems that generate power

	
A lever generates power by_____ ______________________________	A pulley generates power by______ _________________________________
	
A bycicle gear generates power by ______________________________	Air can generate power by _______ ________________________________

How air behaves when it is compressed

How water behaves when it is compressed

Characteristics of an air-filled system of two syringes

Characteristics of a water-filled system of two syringes

Examples of air power	Work that air can do

The pushing power of air can be used to ____

____

____

Unit 8 (Work & Energy):
Power-full Toys

Concept
Hydraulic and pneumatic power can be used to send power through a system.

Content objective
Create a toy that moves by hydraulic or pneumatic power.

Language objectives
Students will describe Design Brief, Black Box Model, and planning map using the *conditional tense*.
Students will explain a hydraulic or a pneumatic mechanism in a complete paragraph using *complex sentences*.

Standards

- **NGSS:**
  - **K-2-ETS1-1.** Ask questions, make observations, and gather information about a situation people want to change to define a problem that can be solved with a new or improved object or tool.
  - **K-2-ETS1-3.** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses. (if the comparison of waterwheels is conducted)
  - **K-2-ETS1-3**. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses.
- **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.
  - **6D** Students will test the effect of force on an object such as a push or a pull, gravity, friction, or magnetism.
- **ELPS**:
  - **1A** Use prior knowledge and experiences to understand meanings in English. [Prior Knowledge]]
  - **3D** Speak using grade-level content area vocabulary in context to internalize new English words and build academic language proficiency. [Application for Acquisition]

- **3H** Narrate, describe, and explain with increasing specificity and detail as more English is acquired.

Materials
- Various construction materials
- Syringes and plastic tubing
- Recycled items, especially cereal and other boxes
- Lesson handouts **4.8.1- 4.8.2**

Literature Connections
The Boy Who Harnessed the Wind: Creating Currents of Electricity and Hope by William Kampkwamba and Bryan Mealer

Day 1: Engage/Explore

Teacher Says/Does	Student Says/Does	Language Requirements
Place the students in teams and ask them to discuss what they know of: a) hydraulic power, and b) pneumatic power. Have students fill out the graphic organizer in handout **4.8.1** and ask volunteers to share their prior knowledge on these two concepts.	Students share their prior knowledge related to hydraulic and pneumatic power Hydraulic power is ______. Pneumatic power is _____.	Hydraulic power Pneumatic power Design Brief Black Box Model Side-view sketch Planning map

Day 2: Explore

Teacher Says/Does	Student Says/Does	Language Requirements
1. Tell students that they will work on a Design Brief in which they use hydraulic or pneumatic power to make moving parts. 2. Show students the following Design Brief: *Design and make a toy to illustrate at least one moving part that works on either hydraulic (water) or pneumatic (air) power.* 3. Remind the students how to begin work on the Design Brief: o Look at the Design Brief. o Ask questions about what the words mean. o When you understand what the words in the Design Brief mean, talk with your partner and plan what you might like to make. o Draw a Black Box Model of your system (review what this means if needed). o Draw a side-view sketch of your device. o Make a planning map. o Talk about who will do what jobs and how you will make sure both people have interesting jobs to do. You may wish to help some of the teams draw their Black Box Models. The students need to decide whether they wish to use water or air as power, and they should think about the kind of motion they wish their device to create. 4. Show students the sample Black Box Model (**4.8.2**) for air power that creates up-and- down (reciprocating) motion. 5. The Black Box Model will help students think about the system they might construct. (They may also choose from gears, pulleys, and levers, as long as the system uses air or water power as input.) 6. Let the teams work on their models.	Students form teams to discuss their design briefs, draw a Black Box Model, and draw a planning map	Hydraulic power Pneumatic power Design Brief Black Box Model Side-view sketch Planning map

Day 3: Explain/ Evaluate

Teacher Says/Does	Student Says/Does	Language Requirements
When the teams have finished their constructions, they should describe in writing what they have made and place their planning maps, side-view sketches, Black Box Models, as well as their device, on display in the Design Gallery. When presenting to the class, students should respond to these questions: o Did your team follow your planning map and sketch in making your device? o Did the Black Box Model help you think about what mechanisms might be needed in your system? o Explain how your device works. Where is hydraulic or pneumatic power used? o Did you have any problems in construction? How did you work those problems out? o What were you thinking when you selected the materials for your project? o Also, ask the rest of the class what questions they have for the team that is presenting.	Students write about their toy, and then make presentations to the class In designing, we decided to _____ because _____. We chose to use _____ for our materials because _____. Our device uses _____ power to _____. We had a hard time _____.	

Hydraulic power in our own words	
Drawing/examples we know	

Pneumatic power in our own words	
Drawing/examples we know	

input --->	**X**	**output**
air in --->		**back-and-forth motion**

Unit 9 (Systems):
"If…, then" Chains in a Gadget

Concept
We can analyze gadgets to find the chain of events that make it work.

Content objective
(Technology Fair) Teams respond to a problem to design a device that will raise a sunken object.

Language objectives
Students will use "if …, then" to orally discuss features of a design.
Students will describe design briefs, black box model, and planning map *using the conditional tense.*
Students will describe experiments using *target vocabulary*.

Standards

a. **NGSS**:
   - **3-PS2-1.** Plan and investigate the effects of balanced and unbalanced forces on the motion of an object.
   - **3-5-ETS1-2.** Generate and compare multiple solutions based on criteria and constraints of the problem.

- **TEKS:**
   - **1A** Students will demonstrate safe practices and use safety equipment.
   - **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.
   - **3A** Students will analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing.
   - **3C** Students will represent the natural world using models.
   - **4A** Students will collect, record, and analyze information using tools.
   - **4B** Students will use safety equipment as appropriate, including safety goggles and gloves.
- **ELPS**:
   - **2G** Students will understand the general meaning, main points, and important details of spoken language ranging from situations in which topics, language, and contexts are familiar to unfamiliar [LC: Abstract & Concrete]

- **3E** Students will share information in cooperative learning interactions. [Communicative Competence]
- **3G** Students will express opinions, ideas, and feelings ranging from communicating single words and short phrases to participating in extended discussions on a variety of social and grade-appropriate academic topics. [Speech Production at Grade Level]

Materials:
- Access to all construction materials
- Dishpan or aquarium and toy boat
- Copy of the Design Brief on a chart

Preparation

Place the plastic toy boat in a dishpan full of water. If you tip the boat so that it fills with water, it will sink. You can also slide a few pennies inside one of its windows to make it lie on the bottom of the "lake."

Literature Connections

Sunken Treasure by Gail Gibbons

Day 1: Engage/Explore:

<table>
<tr><th>Teacher Says/Does</th><th>Student Says/Does</th><th>Language Requirements</th></tr>
<tr><td>

Tell the students that they have learned a lot about materials, mechanisms, energy, and power during their engineering work.
Show students the charts of words and ideas made together and remind students of the Design Gallery creations they have displayed.
Review with students some ideas about materials, levers, gears, pulleys, and hydraulic and pneumatic power systems by having student pairs choose one favorite concept and share with the rest of the class.
Start a web with the following words and ask students to work in groups to connect ideas:

MATERIALS (elastic/shear resistant)
WORK
POWER (transmitted by mechanisms, hydraulics, or pneumatics)
MECHANISMS (gears, pulleys, levers,
wheels, cams) TEAMWORK
PLANNING

Have students add words and connections of their own so that you can hear what they understand about the major concepts.
After each group has built a web together, place it on display for teams to see during the next few periods of work on the Design Brief.

</td><td>Student pairs discuss the features of one chosen engineering concept studied

Student groups create a web connecting engineering concepts</td><td>Gadgets
Materials
Mechanisms
Energy
Power
Engineering
Levers
Gears
Pulleys
Hydraulic power
Pneumatic power</td></tr>
</table>

Day 2: Explore/Explain

<table>
<tr><th>Teacher Says/Does</th><th>Student Says/Does</th><th>Language Requirements</th></tr>
<tr><td>1. Show the students the Design Brief:

Design a device that will raise the sunken (boat) and bring it out of the water —without using your hands to touch the boat and without damaging the boat. Use at least two different mechanisms for movement. You may also use hydraulic or pneumatic power to raise the boat.

2. Remind the students of how to begin work on the Design Brief:
o • Look at the Design Brief.
o • Ask questions about what the words mean.
o When you understand what the words in the Design Brief mean, talk with your partner and plan what you might like to make.
o • Draw a Black Box Model of your system.
o • Draw a side-view sketch of your device.
o • Make a planning map.
3. Talk about who will do what jobs and how you will make sure both people have interesting jobs to do.
4. Let the teams work on their designs, allowing them to try out their models on the sunken toy after they have shown you a planning map, a Black Box Model, and a side-view sketch.</td><td>Students discuss features of a Design Brief and construct a planning map, a Black Box Model, and a side-view sketch.

Students experiment with different options to implement their Design Brief</td><td></td></tr>
</table>

Day 3: Elaborate and Evaluate

Teacher Says/Does	Student Says/Does	Language Requirements
1. When the products are ready, put them on display along with each team's written description of how teams chose to solve the problem and what mechanisms make their devices work. 2. Set up the Design Technology Fair where other teachers and students can see the displays. Be sure to invite parents to visit the Technology Fair. Non-competitive awards can be given to celebrate diversity, creativity, and problem solving expertise!	Students display their products with other students, teachers and parents	