

## Unit 5 (Work & Energy): Black Box Thinking

### Concept

A system is a group of parts working together as a whole; a system has input and output.

### Content Objective

Teams identify input and output components of everyday situations and make side-view sketches of simple work systems. “Black box thinking” is used to analyze folders from other teams in which an event/system is inferred by its input and output.

### Language Objective

Collaborate with peers and ask for clarification when needed.

Explain systems using *target vocabulary*: input, output, system, cause, effect.

Predict the output of a system using *future tense*.

### Standards

- **NGSS:** No NGSS standards apply directly to this lesson.
- **TEKS:**
  - **3A** identify and explain a problem in his/her own words and propose a task and solution for the problem such as lack of water in a habitat (explain prob and solution)
  - **3B** make predictions based on observable patterns (predict from patterns)
  - **3C** identify what a scientist is and explore what different scientists do (connect to adult scientists)
- **ELPS:**
  - **1C** use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary (use strategic learning techniques such as concept mapping, drawing, etc.)
  - **2I** 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 (follow directions, summarize, collaborate with peers)
  - **3D** speak using grade-level content area vocabulary in context to internalize new English words and build academic language proficiency (use vocabulary)
  - **3H** narrate, describe, and explain with increasing specificity and detail as more English is acquired (narrative, describe, explain while speaking)
  - **5G** narrate, describe, and explain with increasing specificity and detail to fulfill content area writing needs as more English is acquired (narrative, describe, explain while writing)

**Materials:**

manila folders (1 per team), construction paper, crayons and markers, glass or cup of water

**Suggested Literature Connections**

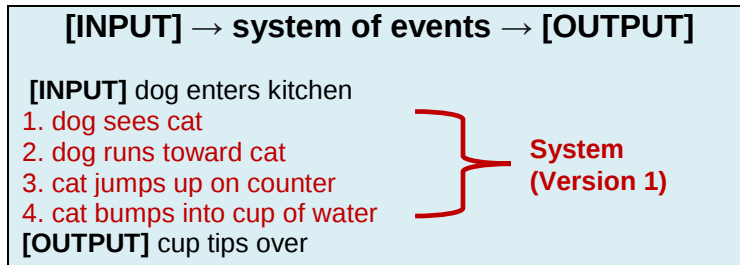
“Pushes and Pulls” by Anna Claybourne

“Push and Pull: The Way Things Move” by Lola Binding

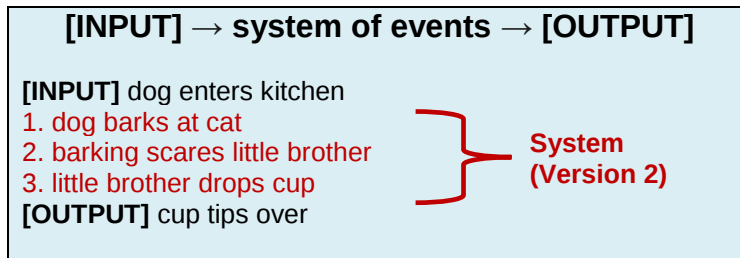
## Day 1: Engage Work & Energy- Black Box Thinking

| Teacher Says/Does                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Student Says/Does                                                                                                                                        | Language requirements                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> <li>1. To have a better sense of the concept that will be covered in this unit, review handout (2.5.1) prior to beginning lesson.</li> <li>2. Without your students seeing, place a small puddle of water on the floor and lay a cup or glass down on its side next to the puddle. Then, when you have the students' attention, ask them what they would think if they came home and found a scene like this: a spilled cup of water. [Note: This will be later called the OUTPUT]. Let them tell their ideas.</li> <li>3. Tell the students that many different things could have happened to make that spill. Ask your students, <i>What do you think <u>happened during</u> the event that lead to the spill?</i> [Note: This will later be called SYSTEM]. Take one of the children's ideas and draw roughly the event she or he feels could have led to the spill, such as the family cat getting startled and bumping into the cup of water. Ask the children, <i>What <u>started</u> the event?</i> [Note: this will later be called the INPUT] then circle the picture that shows that, or draw another. Dog could have entered the kitchen, thus startinling the cat, for example. Then ask, <i>What was the <u>result</u> of those events?</i> [Note: as mentioned earlier, this will be called the OUTPUT]. The water is spilled, and the floor is wet.</li> <li>4. Let them know that this kind of thinking is called "Black Box Thinking" typically implemented by engineers / scientists in which they know what they want to put into a SYSTEM they are designing [INPUT] and what they want to produce out of it [OUTCOME] but the SYSTEM itself is yet to be designed / created. They then get together and go through several rounds of experimentation and hypothesizing until the SYSTEM is formulated / created.</li> </ol> | <p>Student pairs think-pair-share about their inferences for the spill.</p><br><br><br><br><br><br><br><br><br><br><p>Student pairs think-pair-share</p> | <p>Vocabulary:<br/>infer, work, system, input, output</p><br><br><br><br><br><br><br><br><br><br><p>Terminology:</p> <p>INPUT: What goes into a SYSTEM</p> <p>SYSTEM: A series of events / mechanisms with the goal of producing an outcome.</p> <p>OUTPUT: What is produced by the SYSTEM</p> <p>Black Box Thinking:<br/>Hypothesizing on what the SYSTEM is composed of.</p> |

5. Going back to the classroom example, you can tell your students that in your particular example, the water spilled is the OUTPUT of your SYSTEM, the dog entering the kitchen is the INPUT of your SYSTEM, and that your SYSTEM itself is composed of the events that occurred that lead to the water getting spilled. Use the following diagram as a teacher reference:



6. Make sure to fully elaborate the new terminology so that there is no confusion as to what INPUT, SYSTEM, and OUTPUT is.
7. Cover up the events other than the input and output events [or SYSTEM], and ask the children for another sequence of events [or SYSTEM] could have resulted in the same output. Look below for a different example:



Student pairs collaborate on a drawing storyboard with labels and captions. They ask each other and teacher for clarification when needed.

Student pairs converse and hypothesize on different types of SYSTEMS for their classroom example. They ask each other and teacher for clarification when needed.

Question Stems:  
Could you please repeat that?  
What did you mean by \_\_\_\_\_?  
So you think that \_\_\_\_\_?

|                                                                                                                                                                                                                                                                                                                                                 |  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| <p>8. Remind your students that in a broader sense, the system of events or mechanisms is typically blank or unknown, but that the INPUT and OUTPUT can be described in terms of “work” that is done. Tell the students that when you are talking about work here, you mean using energy, such as moving something or making something new.</p> |  |  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

## Day 2: Explore/Explain Work & Energy- Black Box Thinking

| Teacher Says/Does                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Student Says/Does                                                                                                                                                                                                                                                      | Language requirements                                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| <p>1. Ask your students to consider a funny story from their lives or someone they know, and to continue using the following way of thinking:</p> <p style="text-align: center;">INPUT → SYSTEM → OUTPUT</p> <p>2. To do this, the students will be assigned the following design brief:</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p><b>Design Brief: Creating a Black Box Model</b><br/>Create a Black Box Model using a funny story that occurred to you or someone you know.</p> </div> <p>3. Hand your students the handout (2.5.2) in which they will be guided in writing their funny story and separating it into the INPUT, SYSTEM, and OUTPUT sections for the Black Box Model. Students can work individually or in pairs, but encourage them NOT to share their stories with other classmates and to wait until the very end to do so.</p> <p>4. After doing so, the Black Box Model foldables can be created with handout (2.5.3), which also includes instructions on how to assemble.</p> <p>5. Let the teams work on making their foldables in which they will write down their story's INPUT and OUTPUT, and they will write their SYSTEM behind the folded paper so that it is hidden. Encourage them to sketch and color a picture that can go with their SYSTEM from a scene they wish to illustrate. When they are done, they should be ready to discuss the input and output from their system and share their design briefs.</p> | <p>Student pairs share a funny story for their lives.</p> <p>Students draw and write captions using vocabulary.</p> <p>Student teams discuss their design briefs.</p> <p>Student hypothesize different SYSTEMS based on their peers' Black Box Model presentations</p> | <p>Vocabulary:<br/>infer, work, system, input, output</p> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| <ol style="list-style-type: none"> <li>6. Once complete, ask a couple of your students to share their Black Box Model foldables with the SYSTEM section closed, and ask the rest of the class to guess what were those events (or SYSTEM) that occurred between the INPUT and the OUTCOME of the story. You may like to laminate a teacher-example handout so that you can draw and then wipe-off different examples of events inside a black box system.</li> <li>7. Tell your students that they will get an opportunity to write down their predictions later.</li> <li>8. While the students are working, use the <b>collaborative dialogue template</b> (p. 32 in Teacher Handbook) to guide conversations and take a running record of students' progress on content and language objectives.</li> </ol> |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

### Day 3: Elaborate/Evaluate Work & Energy- Black Box Thinking

| Teacher Says/Does                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Student Says/Does                                                                                                                               | Language requirements                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <ol style="list-style-type: none"> <li>1. Review vocabulary from the unit.</li> <li>2. After the teams have had a chance to complete their Black Box foldables, number the foldables and post them around the room.</li> <li>3. Explain how the students should move around the room and now write their predictions about what will happen to produce the output. (Use handout <b>2.5.4</b>).</li> <li>4. While the students are completing their predictions, ask questions like the following:               <ul style="list-style-type: none"> <li><i>What work is going into your SYSTEM? (INPUT)</i></li> <li><i>What work is coming out of your SYSTEM? (OUTPUT)</i></li> <li><i>How well does your prediction match the actual SYSTEM of your peer?</i></li> <li><i>How is your foldable like/unlike those of others?</i></li> </ul> </li> <li>5. Ask the rest of the class what questions they have for the team that is presenting.</li> </ol> | <p>Students use vocabulary words in a sentence.</p><br><br><br><p>Student teams fill out the graphic organizer for the new guessing folder.</p> | <p>Vocabulary:<br/>Infer, work, system, input, output</p><br><br><br><p>I predict that _____ will _____.</p> |

## (Teacher Guide)

### Black Box Modeling

“Black Box Thinking” is a strategy for modeling and predicting used by scientists and engineers who are trying to design systems of various types. This strategy involves thinking about “what will go into the system” (input) and “what will come out of the system” (output). Thinking in terms of input and output helps them identify the things that must happen within the system.

You use this strategy when you are problem solving every day, though you may not use the terminology. For example, you arrive in the library for a staff meeting and discover that you don’t have your glasses. You go back to your room and they are not on your desk. So you think:

“ I had them at lunch in the teachers’ lounge.”

“ They weren’t on my desk after school.”

Working from these two knowns, you begin to concentrate your thinking on what happened in between the times when you were aware of having and not having your glasses.

That “unknown” space, between lunch and after school, is like a Black Box: you can’t see into it, you can only construct guesses as to what’s in it.

Black Box Thinking and Black Box Modeling are introduced to students because of its value as a strategy during the invention process. It is not important whether all of your students comprehend and use the term Black Box Thinking, but they should be able to use “input” and “output,” and they should be able to understand and enjoy the Black Box folders that build understanding of this problem solving strategy.

The basic Black Box Model and two examples are given:

**input  $\Rightarrow$  {X}  $\Rightarrow$  output**

Where **{X}** is the Black box: the unknown system.

FIGURE 14. Basic black box model

### Black Box Model Example 1

**input  $\Rightarrow$  {X}  $\Rightarrow$  output**

girl walks into room  $\Rightarrow$  {X}  $\Rightarrow$  music is playing

**{X}=** A series of events: Perhaps she is walking to the radio, turning it on, adjusting the station and adjusting the volume.

### Black Box Model Example 2

**input  $\Rightarrow$  {X}  $\Rightarrow$  output**

back-and-forth linear motion  $\Rightarrow$  {X}  $\Rightarrow$  rotary motion

**{X}=** A series of mechanisms: Possibly there is a system of levers linked to a wheel and pulley



What happened at the very end of your story? In another words, what was your story's "punchline"? **This will be your story's OUTCOME.**

---

---

---

Now, think of the series of events that occurred between your story's beginning [**INPUT**] and ending [**OUTPUT**] and number them in the order in which these occurred. Remember that you do not need to include your story's INPUT nor OUTPUT, just what happened in-between. You may use as many numbers as you need. **These numbered events will compromise your story's SYSTEM.**

1. 

---
2. 

---
3. 

---
4. 

---
5. 

---
6. 

---
7. 

---
8. 

---
9. 

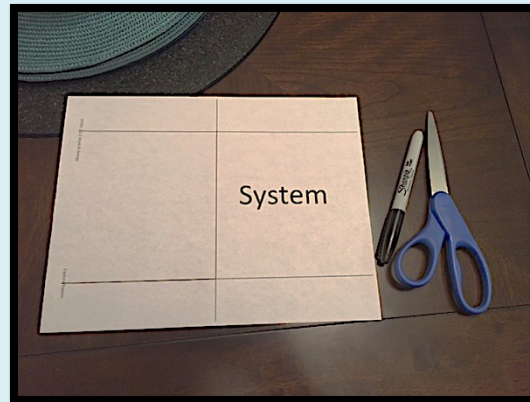
---

# System

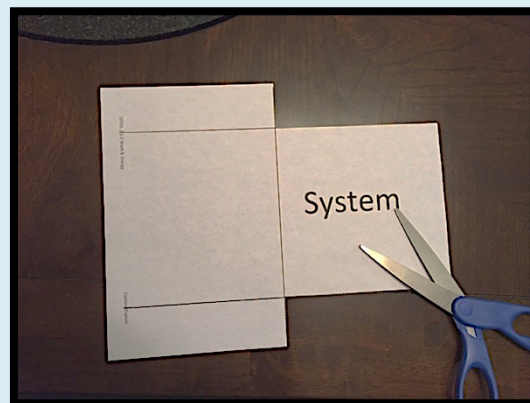
Name: \_\_\_\_\_ Date: \_\_\_\_\_

## Creating my “Black Box Model” foldable

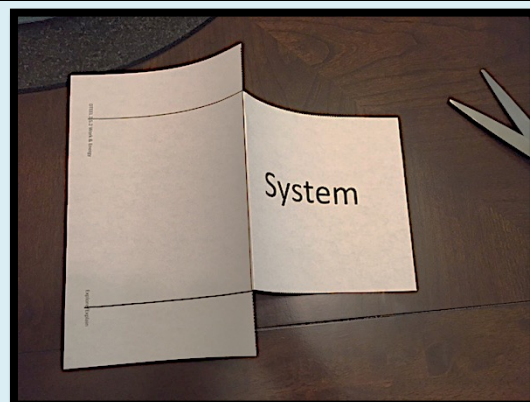
- 1.** Make sure to gather all the materials needed (printout, scissors, pencil or marker).



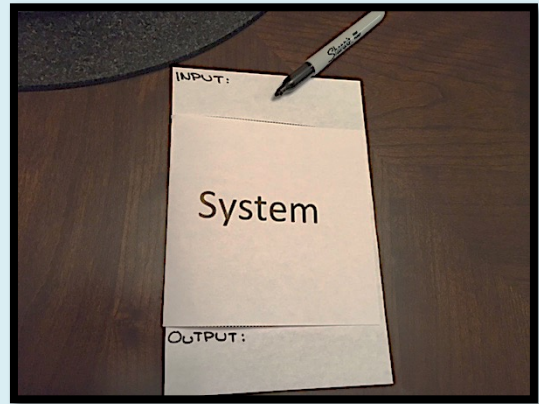
- 2.** Cut the dotted lines only. This will remove 2 rectangles from your foldable.



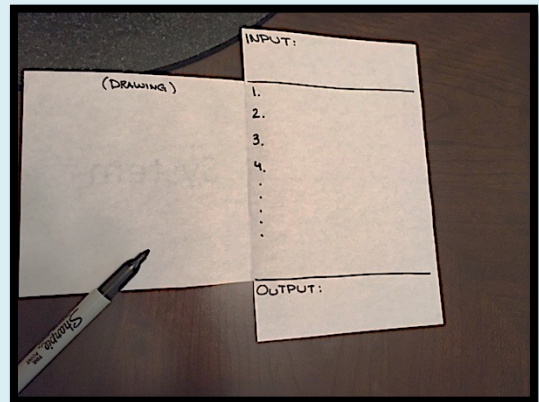
- 3.** Fold your foldable in half or in a “hamburger” style, following the solid line.



- 4.** Once folded, label the top rectangle as your “INPUT” section. It is here where you will write the INPUT or beginning of your story. Label the bottom rectangle as your “OUTPUT” section. Here you will write the OUTPUT or ending of your story.



- 5.** Open the “SYSTEM” section. Number and record the events that happened between the beginning (INPUT) and ending (OUTPUT) of your story. Draw a specific event from your SYSTEM on the left hand side.



## Graphic Organizer for Black Box Thinking

Name \_\_\_\_\_ Date \_\_\_\_\_

Use words and/or pictures to summarize the input and output of each guessing folder. Write your predictions about the inside of the story system in the middle box.

**Folder # \_\_\_\_\_**

| Input |                                                                            | Output |
|-------|----------------------------------------------------------------------------|--------|
|       | I predict that<br>_____ will<br>_____<br>_____<br>_____<br>_____<br>_____. |        |

**Folder # \_\_\_\_\_**

| Input |                                                                            | Output |
|-------|----------------------------------------------------------------------------|--------|
|       | I predict that<br>_____ will<br>_____<br>_____<br>_____<br>_____<br>_____. |        |

**Folder # \_\_\_\_\_**

| Input |                                                                             | Output |
|-------|-----------------------------------------------------------------------------|--------|
|       | I predict that<br>_____ will<br>_____<br>_____<br>_____<br>_____.<br>_____. |        |

**Folder # \_\_\_\_\_**

| Input |                                                                             | Output |
|-------|-----------------------------------------------------------------------------|--------|
|       | I predict that<br>_____ will<br>_____<br>_____<br>_____<br>_____.<br>_____. |        |