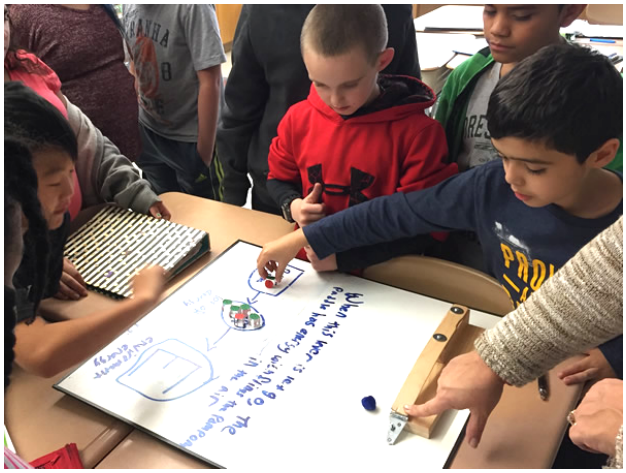
What's the energy story of the paint paddle and the pompom?

Plan Investigation 3B



Today students continue their investigation of motion energy, elastic energy and energy transformation. Students are introduced to energy cubes (see *Energy Cubes Rules* at the end of this investigation) and they then use the cubes to reason about the energy story of the springboard. Energy cubes are an effective tool for representing both the transfer of energy between objects and the *transformation* of energy from one form to another.

In the case of the paint stirrer, elastic energy is transformed into motion energy and vice versa. As the hand pushes down on the tip of the paint paddle, the person transfers energy to the springboard. As the board is deformed, motion energy is transformed into elastic energy. As the springboard is released and returns to its original shape, its elastic energy is transformed into motion energy. Some of that motion energy is transferred to the pompom, and it soars into the air. Some students may notice that the springboard vibrates a bit before becoming motionless. Some of your students may want to use cubes to reason about energy transformations in the vibrating board. You will need to use your judgment about whether or not to engage the whole class in this analysis; the energy of the springboard goes through a rapid series of transformations, back and forth between elastic energy and motion energy.

What do students think about the pompom's energy once it hits the ground and is no longer moving? While the full energy story can be very complex, for now it is sufficient for students to claim that the pompom's motion energy was transferred to the environment.

Learning Targets Introduced in this Investigation

- Energy cubes can be used to reason about energy flows and forms.

Sequence of Experiences		
1. Introduction	All Class	20 Minutes
2. Answer the Investigation Question	Discussion / Pairs	20 Minutes
3. Make Meaning	All Class	20 Minutes
4. Optional: Energy story of diving board?	All Class	

Materials and Preparation

For the class:

- Colored round stickers for labeling the Energy Cubes
- 6 classroom-size (large) Energy Cubes labeled M for Motion Energy on one face and Elas for Elastic Energy on another face.
- A large sheet of paper *
- A colored marker *
- A wooden track and plasticine to level it
- 2 rubber balls (1¼ in. diameter, different colors)
- Optional: Video of a person diving (on the *Focus on Energy* website, in Curriculum Units -> Motion Energy -> Resource Quick Links)
  https://focusonenergy.terc.edu/curriculum/motion/diving_video.html

* A section of whiteboard and erasable markers can substitute for the paper and colored markers.

Materials for each pair of students

For each group of 2 students:

- One "springboard" with pompom
- 6 student-size (small) Energy Cubes labeled M for Motion Energy on one face and Elas for Elastic Energy on another face
- A large sheet of paper and colored markers or a white board and dry erase markers

Preparation:

- Prepare a set of six classroom-sized energy cubes. On each cube, attach one color label on one face, and a second color on another face. Use a fine-tip marker to write M for Motion Energy on one label and Elas for Elastic Energy on the other.

- Prepare a set of six student-size energy cubes for **each pair** of students. Label cubes with an M for Motion Energy on one face and Elas for Elastic Energy on another face.
- Read *An Introduction to Energy Cubes* (includes the Energy Cube Rules) on the *Focus on Energy* website in Motion Energy -> Resource Quick Links.
- Read *Using Sketches to Document Energy Cube Movement* located at the end of this investigation.
- Post the Model of Energy and Energy Cube Rules where all can see them.

1. Introduction

All class – 20 Mins.

If you assigned the *Look for Elastic Objects* homework to your students (See Investigation 3A) you may want to hear about their discoveries before you start this investigation.

Note: Energy cubes and circles provide a powerful option for representing the way energy flows and transforms as it moves through a system. However, energy flow is a dynamic process; it changes from one moment to the next. Therefore, this representation requires that the user always be aware of the moment in time that she/he is representing when using the cubes. In demonstrating the use of energy cubes, be sure your narration highlights the **time** aspect as you move the cubes.

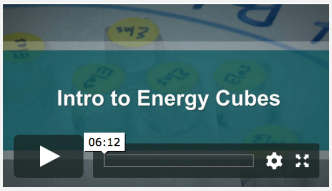
Ask students to gather around a large sheet of paper. Have a colored marker and 6 labeled energy cubes.
Have a demonstration wooden track and 2 balls and a springboard and pompom on hand.

> *You have used sketches, words and energy bars to tell the energy story of colliding balls and of the springboard launching the pompom. Today we learn about another way to tell the energy story, using energy cubes. The cubes will help us think about and explain the flow of energy in a system.*

Tell students that you will introduce energy cubes to tell a familiar energy story: a collision between a moving ball and a stationary ball.

Draw and label two circles, one for Ball #1 and one for Ball #2. Put the name of the object in each circle.

Watch a teacher introduce energy cubes.



Intro to Energy Cubes video available in Resource Quick Links on the Focus on Energy website

Explain that each circle represents an important *component* of the system.

Introduce the energy cubes and discuss the Energy Cube Rules with the class. Highlight these points:

- Each energy cube represents a unit of energy.
- Energy cubes are an excellent way to represent two important energy ideas: energy *transfer* and energy *transformation* as energy moves through a system.
- Slide a cube from one circle to another to show energy transfer (demonstrate).
- Rotate (flip) a cube from one face to another to show energy changing from one form to another – energy transformation (demonstrate). Highlight the practice of flipping the cube at the location where the transformation occurs.
- The total number of energy cubes (usually 6) must always remain the same. Students can add new circles to move the cubes to, but can't add or take away any cubes.

Engage students in using the cubes to tell the energy story (See *Energy Cube Rules*, below). Place Ball #2 half way along the track. Roll Ball #1 toward stationary Ball #2. Stop Ball #1 before the collision.

> *When Ball #1 was moving, before the collision, where should we put the energy cubes? Where was all of the motion energy of this system just before the collision? Explain your answer.*
> ➔ A student puts all 6 cubes in the Ball #1 circle, with "M" up, since Ball #1 is moving and has motion energy. The Ball #2 circle remains empty. It is not yet moving and so has no motion energy.

Note: Slide the cubes from one circle to another. This sliding motion is important. It highlights the fact that the same unit of energy can **transfer** from one place to another.

Roll Ball #1 again, this time letting the two balls collide.

Just after the collision, when Ball #1 has hit Ball #2 and Ball #2 has started to move, what should I do with the cubes?

➔ A student moves four or five cubes to the Ball #2 circle keeping the M side up to show that Ball #2 has gained motion energy. Ball #1 is still moving a bit, so 1 or 2 cubes cube remain in the Ball #1 circle. Emphasize that the exact way the cubes are distributed will depend on the reasoning of the person using the cubes to tell the energy story.

Repeat that the cubes show motion energy of the two balls just a moment after the collision.

Should I turn the cube over to show that there is elastic energy in this collision scenario? [no]

Let students know that they will be using Energy Cubes and circles as they reason together about the energy story of the paint paddle and the pompom. If they have any questions about the Energy Cubes they can ask now.

2. Answer the Investigation Question

Discussion/Pairs – 20 Mins.

Still in the discussion circle, turn to the investigation question,

"What's the energy story of the paint paddle and pompom?"

Explain that students will use energy cubes and circles to tell the energy story of the paint paddle and pompom. Everyone will begin the story when the paint paddle is bent and latched, and the pompom is sitting on top of it. (Show a springboard and pompom in this position.)

- Ask students what circles you should draw and label for this scenario [one for the paint paddle and one for the pompom]. Put the name of the object in each circle.

Refer to the bent and latched paint paddle with a pompom on it.

Before I release the latch, where should we put the energy cubes? Explain your answer.

➔ Put all 6 in the paint paddle circle, with "Elas" up. Nothing is moving and the paint paddle is bent so it has elastic energy.

To reinforce the relationship between Elastic Energy and its indicator—deformation of an object away from its natural shape—hold the paint paddle in position with your finger so it does not move when you release the latch. Let the paddle rise about one third of the way to horizontal and ask:

How many Elastic Energy cubes would you leave in the paint paddle circle now?

➔ Students should suggest removing 1 or 2 cubes.

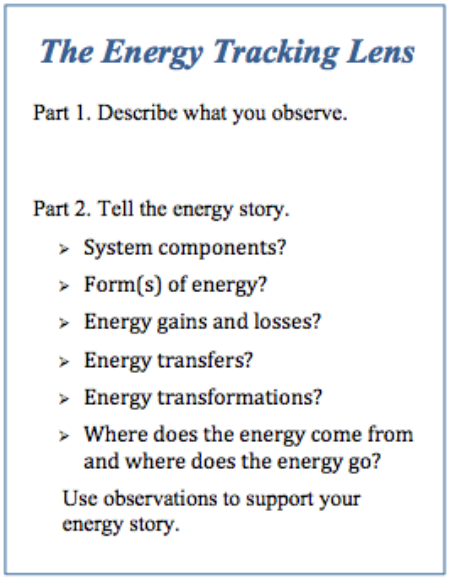
Allow the paddle to rise another third of the way up and repeat the question. Then let the paddle come to its undeformed (horizontal) shape and repeat the question. In its undeformed shape the paddle would have no elastic energy.

Remind students that they can turn over the cubes, leaving the "M" side facing up, to show motion energy.

Mention that as students start to work with their own sets of cubes, they should refer to the Model of Energy they have been developing during the first three classes and is posted on the classroom wall.

Introduce the Energy Tracking Lens

Have students open their Student Notebooks to page 1, **The Energy Tracking Lens**. Some of the questions should already look familiar. Tell students that, from now on, they should refer to the Energy Tracking Lens and think about each question each time they tell an energy story.



Distribute materials

Give each pair of students a large sheet of paper (or whiteboard), colored markers, labeled energy cubes, a springboard, and a pompom. Tell them to use circles and the energy cubes to tell the story about the flow of energy through the springboard and pompom system.

Explain after about 5 minutes they will be asked to share their energy cube stories with the class.

3. Make Meaning

All Class – 20 Mins.

The purpose of this discussion is to share energy stories with classmates, listen to ideas of others and become familiar with the energy cubes as a tool for telling an energy story, including transfers and transformations. At the end of the discussion, you will introduce Energy Flow Diagrams as another way to tell an energy story.

Gather students in a circle and have different groups use cubes and circles to tell their version of the springboard energy story. They should "narrate" the energy story as they move or flip the cubes, explaining their reasoning and describing the evidence that leads them to the decisions they make. Are they addressing the key ideas? Do they

- identify the components of the system?
- talk about the different forms of energy?
- use the terms transfer and transformation as they move or flip the cubes?
- flip the cubes in the correct place to show where the energy transformation occurs?
- describe energy gains and energy losses as energy moves through the system?
- describe where the energy comes from? Where it goes?

Ask students to add on to the energy story. Have the paint paddle and pompom on hand so they can observe additional details.

Some students may notice that the paint paddle is still moving after the pompom is in the air and suggest keeping one or more cubes in the paint paddle circle with the M side up, and moving fewer cubes to the pompom with the M side up.

Some students may notice that as the springboard loses elastic energy, it gains motion energy and suggest that there be both "Elas" cubes and "M" cubes in the springboard circle. They have evidence to support the idea that an object may have two (or more) forms of energy at the same time.

Introduce Energy Flow Diagrams

Make one or two sketches of a consensus energy story, representing a few moments in time, to make a record of the energy story the students developed using cubes. (See *Using Sketches to Document Energy Cube Movement*) Highlight the fact that the number of cubes remains the same: energy does not just disappear or appear from nowhere. Put an "M" or an "Elas" on the face of the cubes. In the next investigation, students will be asked to make their own sketches of an energy story that uses energy cubes.

> **Note**: The drawings in *Using Sketches to Document Energy Cube Movement* provide simplified representations of a complex energy story but represent perfectly good examples of representation as viewed by a student at this point. They address energy form, energy transfer, energy transformation when appropriate, and energy conservation. They also address (within limits) where the energy came from and where it went.

Add to the Model of Energy

Students should be able to add, in their own words, that energy cubes can be used to reason about energy transfers and transformations.

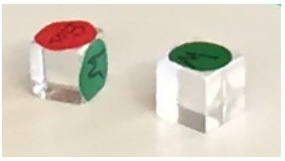
4. Optional: What's the energy story of the diving board? All Class

If you have time, you may ask the students to watch the video of a diver and use energy cubes to tell the energy story.

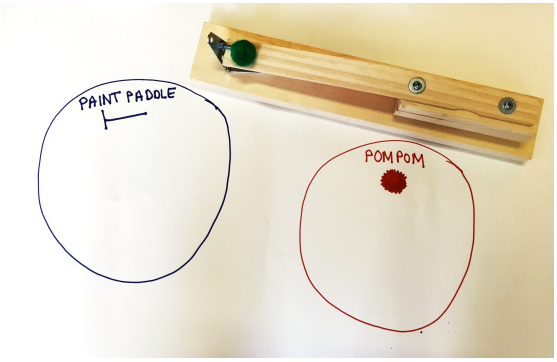
Show the Diving Video available on the *Focus on Energy* website in the Curriculum -> Motion Energy -> Resource Quick Links.

ENERGY CUBE RULES

- Each cube represents an equal-sized unit of energy.



- Circles on a white board or paper represent physical objects that are key components of the system being investigated



- The number of cubes in a circle corresponds to the quantity of energy of the component.

- Each cube indicates its form of energy with a symbol (such as “M” for motion energy) on the side facing up.

- To show energy transformation, flip cubes so that a different symbol (such as “Elas” for elastic energy) faces up.

- The number of cubes showing a particular symbol on the upward side corresponds to the quantity of a particular form.

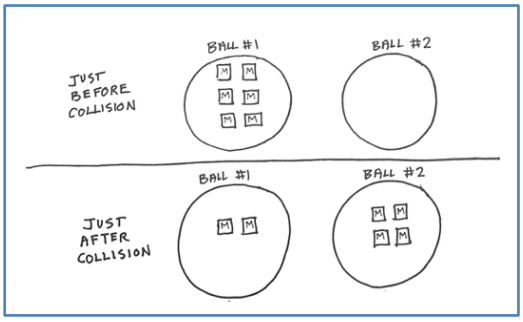
- To show energy transfer, slide cubes from one circle to another.

USING SKETCHES TO DOCUMENT ENERGY CUBE MOVEMENT

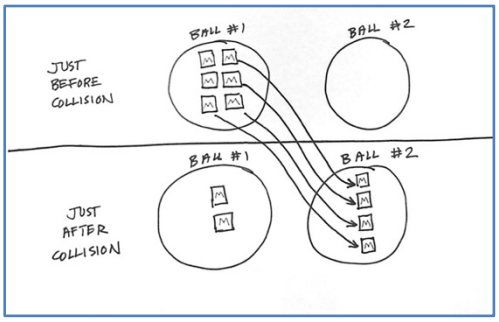
Energy flow through a system is a dynamic process, changing from moment to moment across time and space. Likewise, sliding and flipping the energy cubes through a set of component circles is a dynamic process and a very effective way to represent energy flow through a system. The cubes and circles help students to reason about energy flow and allow them to share their thinking with others involved in the work.

However, the cubes themselves provide no lasting record of student work. This means that students do not have the opportunity to return to a proposal to reconsider it, and teachers have no record of student work to review. A sketch or a photo of the cubes and circles can depict a moment in time but neither is an effective way to capture a dynamic process. The Focus on Energy curriculum therefore suggests that students create a series of sketches that document the location of energy cubes at two or more key points in time, possibly before and after an event, or before, during, and after an event. Below are just three of the many possible approaches to such sketches.

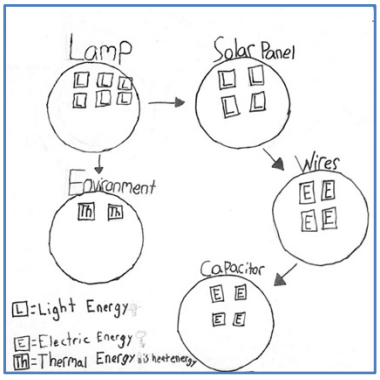
While these sketches are helpful to both the students who developed them and their teachers, they are not meant to inform those who were not involved in the work. They typically do not provide adequate information to be useful for that purpose.



Example #1: This sketch shows the motion energy of two balls immediately before and immediately after Ball #1 collides with stationary Ball #2.



Example #2: This sketch shows the same event of balls colliding as well as the same result in Example #1, but uses arrows to highlights the fact that most of the motion energy of Ball #1 was transferred to Ball #2 during the collision.



Example #3: This sketch uses a different type of representation. Arrows (vs a horizontal line) represent the passage of time as a "batch" of energy, represented by the cubes, moves through the system. Energy starts in the lamp, moves simultaneously to the solar panel and other parts of the environment, then through wires and into the capacitor.