Scope and Sequence: "Energy: Every Day, Everywhere"

Unit Learning Goal: The energy of objects and systems can be transferred and/or transformed. Changes in the energy of objects and systems can be observed and compared.

Unit Central Question: How does the energy of an object or system change?

Anchoring Phenomenon: The distance the rubber band is stretched in a toy car launcher affects the energy of a toy car as evidenced by the speed and distance the car travels.

Lesson	Focus question	Main learning goal	Science content storyline
1	How do we know if something has energy?	We can detect energy (and changes in energy) when an object is moving (and the motion of an object changes). **Science and Engineering Practices** Asking Questions ~~and Defining Problems~~: Ask questions that can be investigated ~~and predict reasonable outcomes based on patterns such as cause and effect relationships.~~ Asking Questions ~~and Defining Problems~~: Ask questions about what would happen if a variable is changed. **Crosscutting Concepts** Systems and System Models: A system can be described in terms of its components and their interactions. Patterns: Patterns of change can be used to make predictions.	Observable changes in a rubber band car launcher system can provide evidence of energy changes (where energy comes from and where it goes) in the system. When the pulled-back rubber band is released, the launcher bar moves forward. Motion indicates an object has energy. As the moving launcher bar collides with the stationary car, the car begins moving and the launcher bar stops. Some of the motion energy of the launcher bar is transferred to the stationary car. This causes the car to begin moving as it gains energy and the launcher bar to stop moving as it has less energy after the collision. The farther the rubber band is stretched, the faster the launcher bar moves and the faster and farther the car moves after the collision.

2	What happens to motion energy when objects collide?	Motion energy can be transferred from object to object through collisions. The faster an object is moving, the more motion energy it has that can be transferred to another object in a collision. **Science and Engineering Practices** Asking Questions ~~and Defining Problems~~: Ask questions about what would happen if a variable is changed. Asking Questions ~~and Defining Problems~~: Ask questions that can be investigated ~~and predict reasonable outcomes~~ based on patterns such as cause and effect relationships. **Crosscutting Concepts** Energy and Matter: Energy can be transferred in various ways and between objects. Patterns: Patterns of change can be used to make predictions.	The faster an object moves, the more motion energy it has. When a moving object collides with a stationary object, the moving object slows down (its motion energy decreases) and the stationary object begins to move faster (its motion energy increases). Because the speed of the objects changes during a collision, this is evidence that the motion energy of the objects also changes. Energy is transferred from a moving marble to a stationary marble during a collision. The faster an object is moving, the more motion (kinetic) energy it has and the more motion (kinetic) energy can be transferred through collisions.
3	How can we change the amount of motion (kinetic) energy of an object?	Position energy (potential energy) can be transformed to motion energy (kinetic energy). The more position energy an object has, the more energy can be transformed to motion energy. As position energy is transformed to motion energy, the object will move faster. **Science and Engineering Practices**	The faster an object moves, the more motion (kinetic) energy it has. As an object goes down an incline, it goes faster and faster as position energy (potential energy) is converted to motion energy (kinetic energy). The higher the incline, the faster the object goes when it moves down the incline. Objects that are not moving can have position (potential) energy. Position (potential) energy can be transformed into energy of motion (kinetic). If the moving object has a collision with another object, energy can be transferred from one object to another and the motion of each object will change. The more motion (kinetic) energy

		Asking Questions ~~and Defining Problems~~: Ask questions about what would happen if a variable is changed. Asking Questions ~~and Defining Problems~~: Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. Constructing Explanations and Designing Solutions: Identify the evidence that supports particular points in an explanation. Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard). Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation ~~or design a solution to a problem~~. **Crosscutting Concepts** Patterns: Patterns of change can be used to make predictions.	an object has, the more energy will be transferred in the collision.
4	How do we know that the energy of an object or system has changed?	The production of heat, light, sound, or motion is evidence that the energy of an object or system has changed. Energy can be changed from one form to another in a variety of ways. **Science and Engineering Practices** Constructing Explanations ~~and Designing Solutions~~: Construct an explanation of	Energy is all around us and can be detected using our senses. We can feel heat, see light, hear sound, and see movement. This is evidence that energy is present and changing. Energy changes in a system can be represented with a system diagram that shows the components of the system, the observable changes taking place, where in the system energy changes are occurring, where the energy comes from, and where the energy goes.

		observed relationships (e.g., the distribution of plants in the backyard). Constructing Explanations ~~and Designing Solutions~~: Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. Constructing Explanations ~~and Designing Solutions~~: Identify the evidence that supports particular points in an explanation. **Crosscutting Concepts** Systems and System Models: A system can be described in terms of its components and their interactions.	
5	Where does the energy come from and where does it go when changes happen in a system?	Energy flows as it is transferred and changed in various ways between objects and in and out of systems. **Science and Engineering Practices** Constructing Explanations ~~and Designing Solutions~~: Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard). Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. Identify the evidence that supports particular points in an explanation. **Crosscutting Concepts**	Energy transfers and changes occur in all interactions. Energy moves from object to object and from place to place, and we detect it in different ways. Energy transfers away from the system through sound, light, or heat. A system diagram can track the energy transfers and transformations that occur in interactions.

		Systems and System Models: A system can be described in terms of its components and their interactions. Energy and Matter in Systems: Energy can be transferred in various ways and between objects.	

Fourth Grade "Energy: Every Day, Everywhere"
Relevant Standards

NGSS 4th grade		Tennessee Standards	
PEs	**SEPs**	**Physical Sciences (PS)**	
4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object. **4-PS3-2:** Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, ~~and electrical currents~~. **4-PS3-3:** Ask questions and predict outcomes about the changes in energy that occur when objects collide.	Asking questions and ~~defining problems~~ • Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. • Ask questions about what would happen if a variable is changed.	**4.PS3: Energy**	Use evidence to explain the cause and effect relationship between the speed of an object and the energy of an object.
	Constructing explanations and ~~designing solutions~~ • Construct an explanation of observed relationships (e.g., the distribution of plants in the backyard). • Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem. • Identify the evidence that supports particular points in an explanation.		Observe and explain the relationship between potential energy and kinetic energy.

DCIs		
PS3.A: Definitions of Energy	The faster a given object is moving, the more energy it possesses. (4-PS3-1)	~~**4.ETS2: Links among engineering, technology, science, and society**~~
	Energy can be moved from place to place by moving objects or through sound, light, ~~or electrical currents~~. (4-PS3-2, 4-PS3-3)	
PS3.B: Conservation of Energy and Energy Transfer	Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2, 4-PS3-3)	
	Light also transfers energy from place to place. (4-PS3-2)	
CCCs		
Energy and Matter • Energy can be transferred in various ways and between objects.		
Systems and System Models • A system can be described in terms of its components and their interactions.		
Patterns • Patterns of change can be used to make predictions. • Patterns can be used as evidence to support an explanation.		

“Energy: Every Day, Everywhere” Kit Handouts and Materials

Materials

Item	Lesson					Notes	Descriptor
	1	2	3	4	5		
Communicating in Scientific Ways poster	X	X	X	X	X	1 color poster per classroom	
Hot Wheels car launcher	X	X	X		X		1 per group of 3
Ruler		X	X			2 rulers **Must have** groove down the middle that extends the full length of the ruler.	
Red and blue marbles		X	X			1 red and 1 blue marble All marbles should be the same size, ~½“ Blue and red marbles (½”, 1 lb = ~80 marbles)	
Blocks of wood			X			3 blocks of wood	
Small piece of Styrofoam			X			Styrofoam sheets will need to be cut like this:  The thickness should be less than or equal to the diameter of the marble. You could use your fingers to break out a notch. It may be worth it to get a Styrofoam cutter. This will help in cutting the small squares.	1 set per group of 3
Red and blue colored pencils		X	X		X	1 red and 1 blue colored pencil 48 count red/blue checking pencils	1 set per student
Plastic bag				X		Resealable bag big enough to hold wind-up toy, noisemaker, flashlight, and rubber ball	
Hand-crank flashlight or shake flashlight				X		Hand-crank flashlight	1 set of each toy in a plastic bag per group of 3 students
Wind-up toy that moves				X			
Noisemaker				X		Use one that you don’t put in your mouth. Purim Gragger Squeaker toy replacements	
Rubber ball				X		1” or 1.5“ (All balls should be identical.)	

Student Handouts

Item	Lesson					Notes	Descriptor
	1	2	3	4	5		
HO 1.1 *Communicating in Scientific Ways*	X	X	X	X	X	1 per student	1 page, color
HO 2.1 *Investigating Energy Changes in Collisions*		X				1 per student	2 pages, may be duplexed
HO 2.2 *Investigating Energy Changes: Analogy Map*		X	X			1 per student	1 page
HO 3.1 *Predicting and Observing Changes in Energy*			X			1 per student	3 pages, may be duplexed Print on 8.5” × 14” (legal-size) paper.
Energy Changes Card Sort Set 1, Set 2			X		X	1 per team of 2 Cut cards in advance; can be reused.	1 page, on cardstock
HO 4.1 *System Diagram: Wind-Up Toy*				X		1 per group of 3 Note: Two groups should be given the same image (HO 4.1–4.4).	1 page, color
HO 4.2 *System Diagram: Hand-Crank Flashlight*				X		1 per group of 3 See note for 4.1.	1 page, color
HO 4.3 *System Diagram: Noisemaker*				X		1 per group of 3 See note for 4.1.	1 page, color
HO 4.4 *System Diagram: Rubber Ball*				X		1 per group of 3 See note for 4.1.	1 page
HO 5.1 *System Diagram: Toy Car Launcher*					X	1 per group of 3	1 page
HO 5.3 *Mumford and Leroy’s Collision*					X	1 per team of 2	3 pages single sided, color

Teacher Resources

Item	Lesson					Notes	Descriptor
	1	2	3	4	5		
TE 2.1 *Investigating Energy Changes in Collisions—Teacher Key*		X				1 for teacher reference	2 pages, color
TE 2.2 *Investigating Energy Changes: Analogy Map—Teacher Key Lesson 2*		X				1 for teacher reference	1 page, color

TE 3.1 *Predicting and Observing Changes in Energy—Teacher Key*			X			1 for teacher reference	3 pages, color Single sided Print on 8.5” × 14” (legal-size) paper.
Teacher Key: Energy Changes Card Sort			X			1 for teacher reference	2 pages, color
TE 4.1 *Teacher Key: System Diagram: Wind-Up Toy*				X		1 for teacher reference	1 page, color
TE 4.2 *Teacher Key: System Diagram: Hand-Crank Flashlight*				X		1 for teacher reference	1 page, color
TE 4.3 *Teacher Key: System Diagram: Noisemaker*				X		1 for teacher reference	1 page, color
TE 4.4 *Teacher Key: System Diagram: Rubber Ball*				X		1 for teacher reference	1 page, color
TE 5.1 *Teacher Key: System Diagram: Toy Car Launcher*					X	1 for teacher reference	1 page, color
TE 5.2 *Mumford and Leroy’s Big Crash!*					X	1 for teacher to read	2 pages, optional color
TE 5.3 *Mumford and Leroy’s Collision—Teacher Key*					X	1 for teacher reference	3 pages single sided, color

General Supplies

Item	Lesson					Notes
	1	2	3	4	5	
Student notebooks	X	X	X	X	X	
Chart paper, chart markers, painter’s tape	X	X	X	X	X	
Glue Stick	X					One per student, can also use tape.
Colored markers				X	X	markers, washable 1 set per group of 3
Plain, white paper, 8.5” × 11”			X			1 piece per group of 3
Transparent tape			X			1 per group 3. A less desirable alternative: the teacher can distribute a length of tape to each group.
Fine-point markers (dark colors: black or dark	X	X	X	X	X	These are used by students to write questions they have on sticky notes to place on the DQB. They need to be markers so that the words are visible to all.

blue; Sharpies work well)						
Sticky notes	**X**	**X**	**X**	**X**	**X**	One pad per group of 3 students. Students may use these in each lesson to add questions to the DQB and for other tasks. The 3” × 3” ones are fine.
Electrical device running in classroom				**X**		Provided by teacher. Students need to be able to feel heat from the device (computers, monitors, and projectors work well).

Using an Anchoring Phenomenon
Lesson 1 in a STeLLA Lesson Set

What is an anchoring phenomenon?
An anchoring phenomenon ("anchor") is a naturally occurring event that causes one to wonder and ask questions. An effective anchor requires an explanation involving the application of multiple science concepts (core ideas), crosscutting concepts, and science or engineering practices--the three dimensions of science learning described by the Next Generation Science Standards (NGSS). The anchor motivates the learning for several if not all lessons in a lesson set. For an engineering-focused lesson, the anchor could be a meaningful design problem. These anchoring phenomena are used to draw students into the storyline by presenting the natural challenge of explaining something or solving a problem grounded in the real world.

What is an anchor lesson, and what is its purpose?
The anchor lesson is used to kick off a lesson set and drive student motivation to learn throughout the lesson set. The purpose of the anchor lesson is to build a shared mission for a learning community to figure out phenomena or solve design problems. More specifically, the anchor lesson serves to ground student learning in a common experience and then use that experience to elicit and feed student curiosity, which will drive learning throughout the lesson set. The anchor lesson also serves as a critical place to elicit students' initial ideas, which are important for both for the students and the teacher. For teachers, this is an opportunity for pre-assessment.

The anchor lesson

- motivates a need for students to know more than they already know.
- sparks student interest and curiosity.
- creates a sense of puzzlement and sets students up for a "need to know" more to either explain a phenomenon, design a solution, or solve a challenge.
- allows the teacher to get a sense of what students already understand about the phenomenon that can be leveraged throughout the unit.
- elicits questions that the students want to investigate and answer throughout the lesson set.

How do students typically represent their thinking as part of the lesson?
The anchor lesson pushes students to represent their initial thinking by writing, drawing, and/or sharing their own initial ideas, models, explanations, or design solutions. These might be represented in their science notebooks. In the anchor lesson, students also raise questions they have about the phenomenon.

What are the main learning goal and focus question for the anchor lesson?
As the launching point for the lesson set, the purpose of the anchor lesson is unique. The anchor lesson is a full lesson designed to draw out students' initial ideas and questions about the phenomenon. Therefore, the main learning goal (MLG) used by teachers and the focus question (FQ) that students will answer should reflect that there is not a specific science

concept that students should learn in the lesson (Strategies A and B in the Science Content Storyline Lens further describe MLG and FQ). Main learning goals for subsequent lessons are the science ideas students should learn to build the science content storyline of the lesson set. These later lessons are designed in a way that students work with their initial ideas to figure out important science ideas or design solutions in the science content storyline of the lesson set.

Typical learning goals and focus questions for the anchor lesson will be similar to this structure:

MLG: Students have many ideas and questions about _(insert overarching science concept or the phenomenon or problem)_ that they can work with to figure out a more scientifically accurate way of thinking.

FQ: What do we know and wonder about _(insert overarching science concept or phenomenon or problem)_?

Typical Design Elements of the Anchor Lesson

Introduce Communicating in Scientific Ways

The anchor lesson will introduce STeLLA Strategy 4, Communicating in Scientific Ways (CSW), to students, if this is new to them. If students have used CSW before, they will find opportunity in the anchor lesson to reacquaint themselves with the strategy and to practice using the sentence starters to communicate with the teacher and their peers. Teachers are asked to display the CSW poster in the room and give students a copy of the poster to attach to their notebook. Sentence starters are introduced or used with students for select rows of the CSW poster the first time students encounter CSW in the lesson. Appropriate rows of the CSW poster to use for the anchor lesson are suggested in the Elements below.

Element 1: Explore the Anchoring Phenomenon

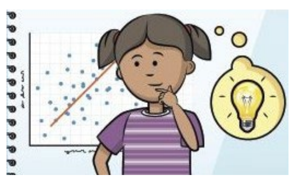
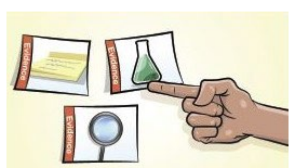
Students are introduced to a puzzling phenomenon that they experience and explore in some way. In this initial exploration, the question the class focuses on is “What do we notice?” For example, students might make observations, look for patterns, or create a timeline of events that occurred. The purpose of this element is for students to recognize the interesting events going on and to publicly, as a learning community, acknowledge aspects of the phenomenon that requires explanation. Students also access their prior knowledge related to the phenomenon that might be useful in exploring and explaining the phenomenon.

Appropriate CSW sentence starters to suggest		
2. Observe.		I see …. I noticed …. I measured ….

Element 2: Attempt to Make Sense

In the "making sense" element, students try to come up with an initial explanation, model, or some other reasoning to explain their thinking about why or how the phenomenon under investigation is happening. The point of this element in the anchor lesson is for students to voice their initial ideas about the phenomenon, no matter how inaccurate or far-fetched they may be. The purpose is to lay a foundation to leverage student ideas and student thinking for the investigations they will conduct throughout the lesson set to help them figure out the scientific explanation or design a solution for a problem. By trying to make sense of the phenomenon, students generate ideas that lead to questions and new ideas that they will want to investigate.

It's important that each student tries individually to make sense of the phenomenon or problem and then go public with his or her ideas. Diversity of ideas and ways of making sense is very productive and exciting! It helps create the sense that we are not all on the same page and that there are things here that beg to be figured out. The role of the teacher in this part of the process is twofold: (1) to help students get their thinking down on the page, regardless of whether it's right or wrong, and (2) to encourage students to come up with their initial ideas for a mechanistic explanation about what's going on. Encourage students to go deeper if they think they know the answer. More likely than not, even students who use correct vocabulary to explain what they think is going on cannot really tell you what those words mean in a mechanistic way.

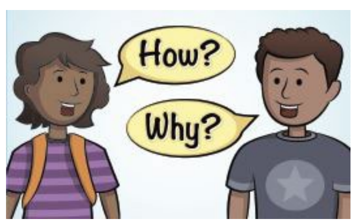
Appropriate CSW sentence starters to suggest		
4. Think of an idea that explains your data and observations		My idea is …. I predict ______ will happen because …. I think what causes this is …. I could draw a picture or diagram to show ….
5. Give evidence for your idea or claim.		My evidence is …. The reason I think that is …. I think it's true because ….
6. Listen to others' ideas and ask clarifying questions.		Are you saying that …? What do you mean when you say …? What is your evidence? Can you say more about …?
7. Agree or disagree with others' ideas; add onto someone else's ideas.		I agree/disagree with _____ because …. I want to add to what _______ said.

<u>Element 3: Pose Questions to Resolve and Discuss Next Steps</u>
In the third element, the class uses a Driving Question Board (DQB) to create a class list of student questions. These are questions that students have about the phenomenon or problem. Generally, answering these questions should help students figure out the mechanism behind the phenomenon, explain the phenomenon, or design a solution to a problem. What's unique about three-dimensional learning is the opportunity for students to be involved in the thought process and decision-making about what the class should be figuring out. It is important for each student to participate in generating a question to be explored and for those questions to be made public so that the class, as a whole, owns and drives their learning.

Connecting to the anchor in subsequent lessons
The class returns to DQB at the end of lessons as appropriate. Returning to the DQB is a way to link what students figured out in the current lesson (or questions on the DQB that they have answered) and what question makes sense to answer next (from those on the DQB or additional questions they add).

This is an example sequence of this element:

- The teacher asks, "What do we want **to know** next?"
  - Students write individual questions.
  - Students share questions aloud.
  - The class organizes the questions on the DQB.

Appropriate CSW sentence starters to suggest		
1. Ask why and how questions.		How come …? I wonder how …? I wonder why …? How do they know that …?

<u>Element 4: Introduce the Unit Central Question as an Overarching Question from Their DQB</u>

After student questions are posted on the DQB, the class helps the teacher organize the questions into categories. The teacher has the main learning goals and focus questions for the upcoming lessons in mind and, as appropriate, groups the DQB questions according to those focus questions. Students' questions won't always fit with the upcoming lesson sequence. They still belong on the DQB but remain as unanswered questions at the end of the lesson set. As you continue to work with new experiences in the lesson set, new questions will emerge that students can add to the DQB.

The unit central question should be one that most questions relate to in some way. Teachers introduce the unit central question and write it across the top of the DQB.

Adapted from Open SciEd Teacher Handbook.