Snap and Pop: Investigating Energy Transformations With Rubber Popper Toys (Resource Exchange)

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Rachelle Pedersen recently finished her Ph.D. Texas A&M studying Curriculum & Instruction (Emphasis in Engineering & Science Education). Additionally, she has a M.S. in Curriculum & Instruction from Texas A&M University and a B.S. in Engineering Science (Technology Education) from Colorado State University. Her research focuses on motivation and social influences (e.g. mentoring and identity development) that support underrepresented students in STEM fields. Prior to graduate school, Rachelle taught high school technology and engineering education (Robotics/Engineering, AP Computer Science, and Video Production).

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Snap and Pop!

INVESTIGATING ENERGY TRANSFORMATIONS WITH RUBBER POPPER TOYS

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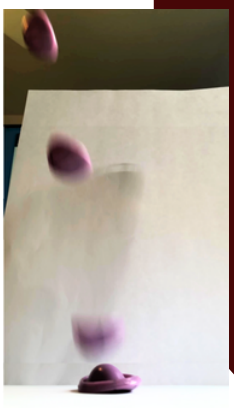

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LESSON DESCRIPTION

This lesson is a mix of demonstrations and inquiry experiences intended to guide students through concepts of energy transformations (e.g., kinetic, elastic) and engineering concepts of snap-through transitions in both the natural and engineered world. Students will develop foundational understandings of energy conservation with a simple ball bouncing demonstration and build to more complex concepts of spring/elastic energy using the classic 90's rubber popper toys to investigate the energy transformations in the system. Depending on the age of the students, we will extend this lesson to discuss the snap-through transition happening with the popper toy and connect this idea to real-world examples (e.g., venus flytrap). From there, students will develop experiments to investigate how they can manipulate the height of the popper through various energy transformations (e.g., collisions, heat).

GRADE LEVEL

Middle or High School

SAFETY

Due to the sporadic nature of the poppers, students should always wear safety glasses.

MATERIALS

- Rubber Popper Toys
- Tennis Ball
- Spring
- Measuring Tape
- Large Grid Paper (or similar)
- Video Camera
- Safety Glasses

EST. TIME

~90 Minutes

EXAMPLE GOALS AND NGSS ALIGNMENTS

Student goals: Critical thinking, communication, drawings models

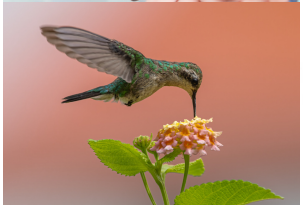
Concepts: Kinetic, spring/elastic, sound energy, snap-through transitions (stored elastic energy)

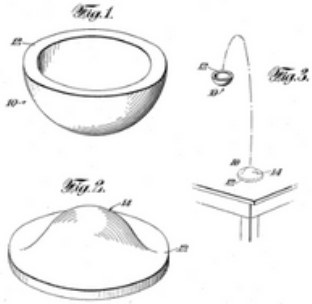
NGSS Standards and Cross-Cutting Concepts:

- Energy may take different forms (e.g. thermal energy, energy of motion). (MS-PS3-5) (HS-PS3-2)
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4)
- Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution. (HS-PS3-4)

ENGINEERED AND NATURAL WORLD CONNECTIONS

Energy and energy transformations are essential for engineers to understand as they utilize their conceptual understandings to minimize/maximize transformations in designed systems. Most recently, biomedical engineers have mimicked snap-through transformations with medical devices like artificial heart valves. In nature, we can see snap-through transformations and rapid energy transfers with the leaf of a Venus Flytrap or the quick clamping of a Hummingbird's beak.





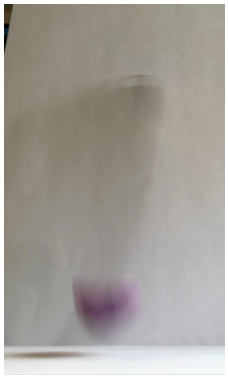
Popper Toy: Elastic object rapidly jumping from one state to another Invented by Jerome Davis in 1939

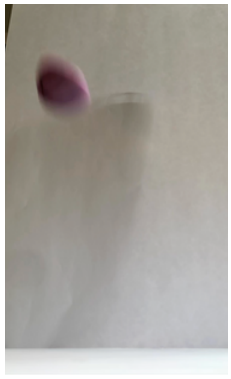
IDEA #1: ENERGY CANNOT BE CREATED NOR DESTROYED,BUT CAN BE CONVERTED/TRANSFERRED

Through demonstration and lines of questioning, the teacher will showcase how energy is transferred during a collision by dropping a tennis ball and seeing that the ball does not bounce as high as it was dropped. Address that energy was not lost, but transferred through various means (e.g., the floor, air resistance, sound, heat). (MS-PS3-5) (HS-PS3-1) (HS-PS3-4)

IDEA #2: ENERGY CAN BE STORED IN A SPRING

To demonstrate that energy is stored in a spring, have students pull on either side of a tension spring. They will notice that the more they want to pull the spring apart, the more energy they need to use to do so. When they release, the spring will go back to its original state. Next, students will investigate how energy is stored in a spring-like system using a rubber popper toy. When the toy sits on the ground inverted, potential energy is stored as is elastic energy of a spring. When the toy flips inside out, it collides with the ground and potential/elastic energy is converted to kinetic energy, launching it up!

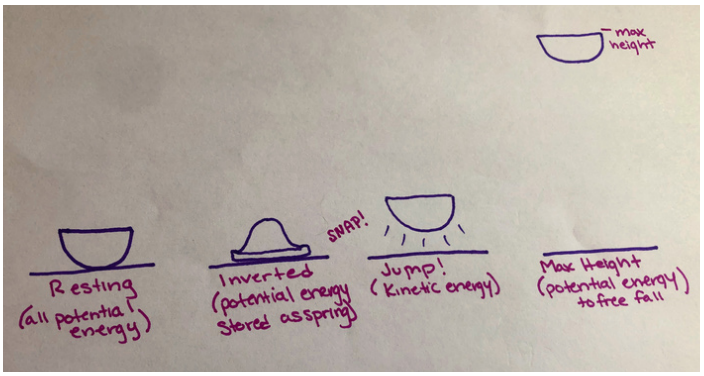




Investigation: Using popper toys, students will conduct an investigation to determine the approximate height a popper jumps, eventually incorporating additional variables, such as popper size, time held inverted, surface popped from. For each new investigation, students should document data and observations and report on the relationships found as related to energy transformations. As an extension, high school students might calculate the relative value of a "spring constant" of the popper toy using their understanding of potential energy, kinetic energy, and springs through these equations: $PE = \frac{1}{2}kx^2$ $U = mgh$

(OPTIONAL) IDEA #3: INSTABILITY IN THE POPPER LEADS TO A SNAP-THROUGH TRANSITION

Discussions on what is happening at a microscopic level may be relevant for high school students as they investigate how the inverted popper has unstable particles that seek to reach equilibrium, going from a steady state, to in-motion, back to steady. (HS-PS3-4) Students might draw the tension and compression of the system to represent internal molecular forces within the popper at each stage.



EXAMPLE INVESTIGATION EXTENSIONS

NGSS ALIGNMENT	CONCEPT	INVESTIGATION EXTENSION
(HS-PS3-3)	Thermal Energy	Place poppers in ice baths and/or hot water to manipulate popper temperature and investigate the impact of temperature differences on popper height.
(HS-PS2-2)	Collisions/Momentum	Place one popper on top of another and investigate how energy is transferred from one popper to the other.
(HS-PS3-4)	Investigations, Reliable Measures	Due to the sporadic nature and variability in pop height/motion, determine ways to develop more consistent/reliable measurements (e.g., launching pad)
(HS-PS2-6)	Molecular Structure and Geometric Properties	Change the size of the popper to investigate how geometric features impact the popper height.