Science Unit: ***Energy and Motion in Man and Machine***
Lesson # 1: ***Experimental Design: Potential and Kinetic Energy***

Summary:	Students built an "**exploding popsicle stick chain**" to visualize **potential energy**. They also discussed forms of energy and correlation versus causation.
School Year:	2014/15
Developed for:	Beaconsfield Elementary School, Vancouver School District
Developed by:	Sheila Thornton (scientist); Susan Worthington and Angela Ward (teachers)
Grade level:	Presented to grade 5/6/7
Duration of lesson:	1 hour and 20 minutes
Notes:	Set up time required for the popsicle stick demonstration

Objectives

1. Understand hypothesis-driven science
2. Introduce the concept of energy
3. Develop an appreciation for potential *vs.* kinetic energy

Background Information

To paraphrase the **First Law of Thermodynamics** (*thermos* meaning "heat", and *dynamics*, meaning "power"): energy is neither created nor destroyed, only transferred from one form to another. This is the mantra for the unit, and each lesson explores the concept of energy transfer, moving between the physical and biological examples.

The **Second Law of Thermodynamics** indicates that this transfer is not perfect (it actually states something closer to the following: "every natural thermodynamic process proceeds in the sense in which the sum of the entropies of all bodies taking part in the process is increased"). For example, in many transfers, some of the energy is "lost" to the environment in the form of heat. It also explains why a perpetual motion machine is an impossibility (provide example of a pendulum or a playground swing (https://www.youtube.com/watch?v=xXXF2C-vrQE) that, once released, will eventually stop moving).

Vocabulary

Potential energy	Any type of stored energy; it isn't shown through movement.
Kinetic energy	The energy of movement. May include chemical, gravitational, mechanical or nuclear.
Hypothesis	A **hypothesis** (plural *hypotheses*) is a proposed explanation for a phenomenon. For a hypothesis to be a **scientific hypothesis**, it must be testable.
Correlation	A relationship of two or more things- this relationship may be positive or negative. For example*, Studies find a positive correlation between the grade they earn and the amount of time spent studying. They may also find a positive correlation between the grades that they earn and the number of carrots they consume.*
Causation	Causation is the relationship between an event (the *cause*) and a second event (the *effect*), where the second event is a result of the first.

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Materials

Popsicle sticks (~50 per group) 4 colours most helpful

In the Classroom

Introductory Discussion

1. What is energy?

Energy is the ability to do work. What is work? In physics, when force acts upon an object to cause displacement of the object, it is said that **work** was done upon the object. Examples include a hammer swinging onto a nail; an engine moving a car; a boy throwing a ball.

Energy can be potential (that is, unreleased or stored) and can be described as the difference in energy between two states. This potential can be held in many different forms:

Chemical

Atoms make up the universe and also all life. Too small to be seen with the eye or a regular microscope, atoms can stick together to form *molecules*. These atoms are bonded together, and the **chemical energy** is stored in the bonds of molecules. A single molecule can be small, built of just two or three atoms, or it can consist hundreds of atoms, like in a strand of DNA, or of trillions of atoms.

This stored energy is released and absorbed when bonds are broken and new bonds are formed -*chemical reactions*. Chemical reactions change the way atoms are arranged. Like letters of the alphabet that can be rearranged to form new words with very different meanings, atoms go through chemical reactions to be reorganized to form new compounds with vastly different properties. Each compound has its own **chemical energy** associated with the bonds between the atoms it contains.

Gravitational

Systems can build up **gravitational energy** as they move away from the center of Earth. For example, the farther you lift an anvil away from the ground, the more potential energy it gains. The energy used to lift the anvil is called **work,** and the more work performed, the more potential energy the anvil gains. If the anvil is dropped, that potential energy becomes **kinetic energy** as the anvil moves faster and faster toward Earth. There is potential energy in any object on an **inclined plane**, due to the gravitational force on the object and the kinetic energy of the object when it begins to roll down the plane.

Elastic

Elastic energy can be stored mechanically in a compressed gas or liquid, a coiled spring, or a stretched elastic band. On an atomic scale, the basis for the energy is a reversible strain placed on the bonds between atoms, meaning there's no permanent change to the material. These bonds absorb energy as they are stressed, and release that energy as they are relaxed.

Nuclear

Nuclear energy is the stored potential of the nucleus, or center, of an individual atom. Most atoms are stable on Earth; they retain their identities as particular elements, like hydrogen, helium, iron, and carbon, as identified in the Periodic Table of Elements. *Nuclear reactions* change the fundamental identity of elements.

Unlike everyday *chemical reactions* that change how atoms are stuck together (rearranging the letters of a word), nuclear reactions change the name of the atoms themselves. (Sort of as if the letter "m" was split into the letters "r" and "n," or the letters "l" and "o" combined to make the letter "b"). In nuclear reactions, atoms split apart or join together to form new kinds of atoms, called *fission* and *fusion*, respectively. When atoms split apart or fuse together, they release stored nuclear energy, sometimes in huge quantities.

Today's nuclear power plants are fuelled by *fission*, a breaking apart of uranium or plutonium atoms that releases lots of energy. Hydrogen atoms in the sun experience *nuclear fusion*, combining to form helium and subsequently releasing large amounts of energy in the form of electromagnetic radiation or heat. Once released, this energy is available to do work. We then refer to it as ***kinetic energy*.**

Kinetic Energy

The energy of movement – the motion of objects. This could be the movement of planets or people; the vibrations of atoms by sound waves, or by thermal energy (heat); the motion of electrons in electricity.

Each form of energy can be transformed into any of the other forms, but energy isn't destroyed or created. "Losses" of energy can always be accounted for by small transformations to other types of energy, like sound and heat. Power plants convert potential energy or kinetic energy into electricity, a type of kinetic energy, and electricity in turn can be transferred into other forms of energy, like heat in an oven or light from a lamp.

Exercise 1

1. Provide example for students regarding energy transfer and the concept of *correlation* have the students stand up and on the count of three, JUMP in the air. Then, ask them:

    - "*What would you say if I observed that, at the exact moment you landed, a 6.3 magnitude earthquake occurred in Peru? (A country generally not known for its seismic events)*" (OPTION: Run a PowerPoint slide of a seismograph exactly when they land – simple method is an image of a seismograph, animated to appear with "wipe left, medium speed"; use two or three different images for repeats).
    - Did the kinetic energy from the jump somehow initiate the release of energy from the Earth's crust and form an earthquake?
    - How would you test this to see if this event *caused* or was *correlated* with the earthquake?
    - How many times would you have to test this to accept or reject the hypothesis?

2. Use this example to explore the concept of correlation vs. causation, and the importance of posing a testable question (i.e., developing an hypothesis).

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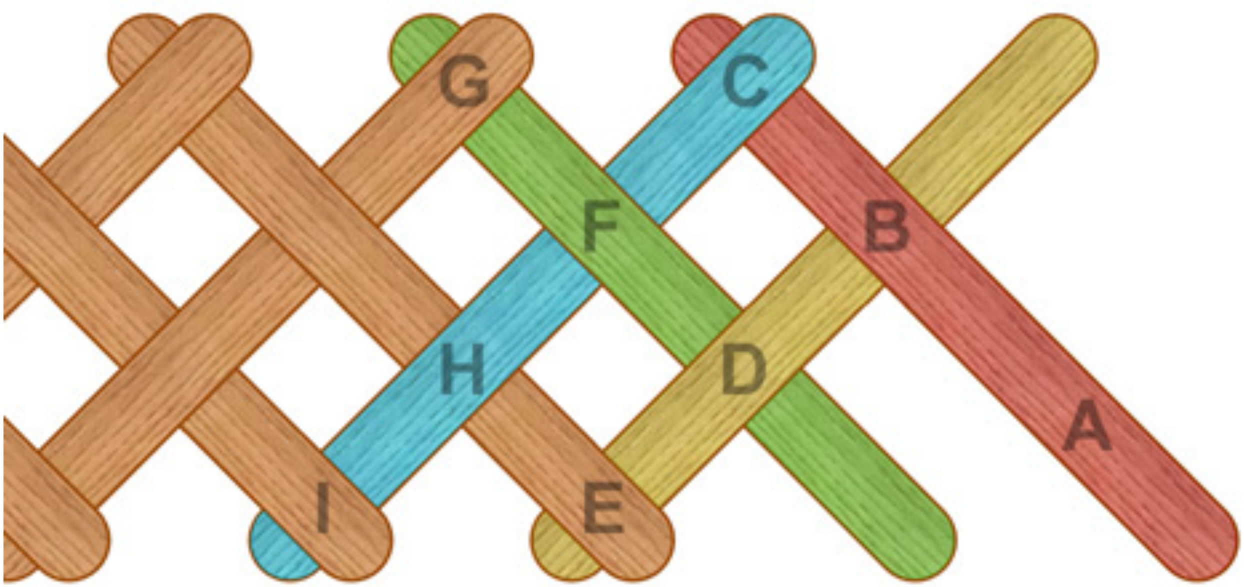
Exercise 2

Popsicle Stick Demonstration

(Teachers and scientists need to prepare the chain prior to class)

Discuss and demonstrate potential energy – book falling off table; flexing popsicle sticks – ask students to name what kind of potential energy may be in each item (e.g., popsicle stick has chemical energy, which could be released when it is burned; it has elastic energy when it flexes (snap it on the table).

Demonstrate the shift from potential to kinetic energy by releasing the popsicle stick chain (see instructions below for set-up). There are also many videos of this available on line.



Begin by crossing the red stick over the yellow. Slide the green underneath the yellow, then weave the blue under the green and over the red. Continue on with this under/over pattern (E goes under the blue, over the yellow; I goes under G and over H). When you have a chain of sufficient length (the longer it is, the more impressive the release), place a book or another heavy object on the end of the chain. To release, just lift the book and stand back.

Exercise 3

Split the students into groups and provide them with popsicle sticks. Instruct them as to how to build a popsicle stick chain.

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Closure Discussion

Review the concepts of the First and Second Laws of Thermodynamics. Students transfer energy from their muscles (which use potential energy in the form of chemical bonds – ATP – to do work) into the popsicle stick. This potential energy is held in the elastic properties of the wood until released as kinetic energy – movement.

Ask the students how much energy they needed to undertake this exercise. Then ask them if they think they could be more efficient in their energy transfer (i.e., could they make the popsicle stick chain using *less* energy than they expended?). Students will likely answer **yes**, as they will experience difficulty, at least initially, in building their chain.

Introduce the concept of optimality and efficiency. The more efficient the energy transfer is, the closer the system is to optimal function. For example, if an animal is an optimal forager, it expends the least amount of energy for the most amount of gain.

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