I. ENERGY AT PLAY

Energize your students with this exploration of the way energy transforms and transfers. Using Tinker Toys™, household items and their knowledge, students build fun contraptions that will make a ball move and hit a target.

Grade Levels: 3-6

Educational Outcomes:

1) Students will be able to identify the Potential Energy stored in various objects.
2) Students will be able to identify the form of Potential Energy (gravitational or elastic) stored in various objects.
3) Students will be able to identify the Kinetic Energy of various objects.
4) Students will develop a deeper understanding of the Law of Conservation of Energy.

Estimated Time: 1.5 hours

- Introductory Design Challenge Activity: 20 min.
- Basic Science Discussion (Mechanical Energy & Conservation of Energy): 15 minutes
- Design Challenge:
    - Building – 40 minutes
    - Sharing – 10 minutes
- Wrap-up and Clean up: 5 min.

Science Standards Connections:

Grade 3 - Physical Science: Energy and matter have multiple forms and can be changed from one form to another.

Grade 6 - Physical Science: Students know energy can be carried from one place to another by heat flow or by waves, including water, light and sound waves, or by moving objects.

All grades - Investigation and Experimentation: Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations.

Tech Gallery Connections: Innovation: Virtual Design – Design a Bike, Design & Ride a Rollercoaster; Life Tech: Beyond our Limits – Human-Powered Vehicles; Big Ball Machine – energy and motion, transfer of energy; Imagination Playground

II. ENERGY AT PLAY: ADVANCED PREP AND SET-UP

Introductory Design Challenge:
Each team of two to three will have:

- One set of plastic Tinker Toys
- Velcro balls

Student research station (items can vary)

- Spring-driven top
- Spring loaded Frisbee gun
- Ball on elastic band
- Bouncy ball
- Slinky
- Magic Wheel
- Toy Catapult & Rubber animals
- Wind up animals/cars

Demonstration Table/Teacher Station

- Newton's Cradle
- Student research station toys

Poster for wall: Law of Conservation of Energy

Design Challenge:
Each team of two to three will have:

- One set of plastic Tinker Toys
- Velcro target and Velcro balls

General supplies available to everyone (from long table on side of room):

- Balloons
- Rubber bands
- Paper cups
- Tongue Depressors
- String
- Tape
- Drinking straws
- Pipe cleaners
- Cardboard/heavy paper
- Extra Tinker Toys (purple and green)

III. ENERGY AT PLAY: LESSON PLAN

A. Introduction: Talk about how this class is all about playing with Energy. Some of the energy that toys use is stored energy; ready to leap into action (wind up a spring loaded top) and some of the energy is in motion (release the spring loaded top). We can use our own force to store energy (pull back on sling slot) or we can use gravity (drop a ball or let go of basketball hanging from rope) to store the energy for us. But to get a better idea of how energy works with toys, we're going to ask you to build your own toy!

B. Mini Design Challenge: Energy at Play Part I

Challenge: Due to the popularity of The Tech's Ball Machine, our gift shop has received many requests from museum guests to sell a smaller version of it. Your job is to design a unique Ball Machine that will be sold as a toy in The Tech's gift shop! Your challenge is to build a simple toy with it's own propulsion mechanism that will move a ball at least 5 inches (without using your energy to directly move it).

Constraints:

- Your ball must move at least 5 inches, without using your energy to directly move it.
- Your toy must store and transform energy in some way to move your ball.
- You can only use the materials allowed.
- Each group member must participate in the design, construction, and operation of the toy.
- You will be allowed to test your toy as you work.

DC Demonstration and Reflection:

Demonstration: Have students demonstrate their device at their tables for the class. If students have not completed their device ask them *how the device would have worked.*

Reflection: Each group of students will explain their design strategy and how their device uses energy, forces, and motion. Instructor should ask leading questions to get at the science behind the designs.

Energy:
The capacity to do work.

Force:
A push or pull upon an object resulting from the object's interaction with another object.

Mechanical Energy:
Energy possessed by an object due to its motion or its stored energy of position. Mechanical energy can be either kinetic energy (energy of motion) or potential energy (stored energy of position).

Work:
A force acting on an object to move it across a distance. Pushing, pulling, and lifting are common forms of work.

Note to teachers:
The Research station is to be set up a specific location in the lab. It should contain toys, gadgets and specific K'nex building strategies and examples. (Please refer to setup guide for a list of supplies). Students should be encouraged to play with objects to get an idea of how they work.

Teaching Points:

- Potential Energy is stored Energy
- Kinetic Energy is Energy in motion
- Potential Energy can be either gravitational (gravity) or elastic (rubber bands, springs...).

Questions to Encourage Teaching Points:

- How is the energy stored in your toy? How does energy transfer in your toy?
- Do you know what these different types of energy are called? (PE is stored Energy, KE is Energy in motion.)
- Do you know what types of Potential Energy are being demonstrated by your toy design? (PE can be either gravitational or elastic.) *Continue to identify the PE and KE of the various toys and the form of PE being used.*

C. Law of Conservation of Energy (Demonstration & Discussion)

1. Newton's Cradle Demo:

Demonstrate Newton's Cradle in action. Instructor should ask leading questions to get at the science behind the cradle. Pull answers and innate understanding from students.

Note: an online simulation of Newton's Cradle can be found at: http://home.a-city.de/walter.fendt/physengl/newtonscradle.htm

Teaching Points (Conservation of Energy):

- Energy is **transformed** from potential to kinetic
- Energy is **transferred** from one ball to the next
- Energy is **transferred** to air and **transformed** into heat
- Friction and air resistance convert or **transform** the Mechanical Energy into heat

Questions to Encourage Teaching Points:

- How does this work?
- Does the energy transfer?
- Does the energy transform/ change?
- Why does it slow down?
- Where does the energy go?

Kinetic Energy:
Energy of Motion. Includes heat, sound, and light (motion of molecules).

Potential Energy:
Energy of position; energy that is stored and held in readiness. Includes chemical energy, such as fossil fuels, electric batteries, and the food we eat.

Elastic Potential Energy:
Potential energy due to tension -- either stretch (rubber bands, etc.) or compression (springs, etc.).

Gravitational Potential Energy:
Potential energy stored in an object as a result of its vertical position (i.e., height).

2. Introduce Research Station Toys

Introduce various toys from research station. Make sure to have a good variety of toys that demonstrate gravitational potential energy (e.g. yo-yo, magic wheel, bouncy balls), elastic potential energy (e.g. wind-up toys, sling shots), and both gravitational and elastic potential energy (e.g. slinky). Also make sure that you have toys that transfer energy to another object (e.g. catapult, slingshot).

Question to Encourage Teaching Points:

- What type of potential energy does this toy store?
- Does this toy transform energy? When? How?
- Do any of these toys transfer energy to another object? Which ones?

Let students know that these toys will be available for them to research further, as they rework their toy designs.

3. Introduce Law of Conservation of Energy (posted on wall)

Energy cannot be created or destroyed; it may be transformed from one form into another, or transferred from one place to another, the total amount of energy never changes.

D. Design Challenge: Energy at Play Part II

Challenge/Scenario: Building on what you learned from your design in Part I, your job is to design a more sophisticated Ball Machine that will be sold as a toy in The Tech's gift shop. Your Ball Machine must both transform potential energy (elastic or gravitational) to kinetic energy as well as transfer energy to a ball to make it move 1 meter to hit a target.

Constraints:

- Your Ball Machine must show and you should be able to explain: the kind of potential energy your device stores, how that potential energy is transformed to kinetic, and where that energy goes after being transferred to the ball.
- You can use your original design or create something completely new.
- The ball must travel about 1 linear meter in any direction) to the target.

Note to teachers:

The Research station is to be set up a specific location in the lab. It should contain a wide array of toys. (Please refer to setup guide for a list of supplies).

Students should be encouraged to play with objects to get an idea of how they work.

- You can place your target in any orientation or location.
- You can only use the materials provided.
- You can visit the research station at any time to get ideas for your design.
- Each group member must participate in the design, construction, and operation of the device.
- You will be allowed to test your device as you work.

E. Demonstration and Reflection:

Demonstration: Have students demonstrate their device for the class, at their tables. If students have not completed their device ask them *how the device would have worked.*

Reflection: Each group of students will explain their design strategy and how their device uses energy, forces, and motion. The Instructor should ask leading questions and point out other facets of the student's designs (i.e.: simple machines).

Questions to Elicit Student Thinking and Understanding:

- Did you continue to work on your original design or try something new?
- How does your toy transform potential energy (elastic or gravitational) to kinetic energy?
- How does your toy transfer energy to the ball to make it move?
- Did you do any research to inform your design? How did it help you?
- If you had more time what would you add, change, or do differently?

F. Clean up: **Reduce! Re-use! Recycle!**

Only throw away items that cannot be re-used. All items should be returned to the appropriate place.

IV. ENERGY AT PLAY: TEACHER NOTES

Glossary & Concepts:

Physics Terms

- Conservation of Energy: Energy cannot be created or destroyed; it may be transformed from one form into another, or transferred from one place to another, but the total amount of energy never changes.
- Energy: The capacity to do work. Measured in joules. Appears in many forms, most of which are ultimately derived from the sun or from radioactivity.
- Gravitational Potential Energy: Potential energy due to elevated position. Gravitation potential energy = weight x height. Note this only depends on vertical displacement and not the path taken to get it there. This value is always relative to some reference level.
- Elastic Potential Energy: Potential energy due to tension -- either stretch (rubber bands, etc.) or compression (springs, etc.).
- Force: A push or pull upon an object resulting from the object's interaction with another object.
- Kinetic Energy (KE): Energy of motion. KE= _ mass x velocity^2 = _ mv^2 Note that small changes in speed can result in large changes of KE (it's speed squared!). Net force x distance = KE. Includes heat, sound, and light (motion of molecules). KE is a scalar quantity; it cannot be canceled.
- Mechanical Energy: Energy possessed by an object due to its motion or its stored energy of position. Mechanical energy can be either kinetic energy (energy of motion) or potential energy (stored energy of position).
- Potential Energy (PE): Energy of position; energy that is stored and held in readiness. Includes chemical energy, such as fossil fuels, electric batteries, and the food we eat.
- Work: A force acting on an object to move it across a distance. Pushing, pulling, and lifting are common forms of work.

Resources:

- *Conceptual Physics for Parents and Teachers: Mechanics* by Paul Hewitt. Focus Publishing/ R. Pullins Company, Newburyport, MA. 1998.
- *Exploring Energy with Toys* by Beverley A. P. Taylor. Terrific Science Press, Middletown, OH, 1998.
- *Gizmos & Gadgets: Creating Science Contraptions That Work (& Knowing Why)* by Jill Frankel Hauser and Michael Kline. Williamson Publishing, 1999.
- *Teaching Physics with Toys: Activities for Grades K-9* by Beverley A. P. Taylor, James Poth, and Dwight J. Portman. McGraw-Hill Trade, 1995.
- *The Inventa Book of Mechanisms* by Dave Catlin. Valiant Technology Ltd., London, England, U.K., 1995.
- *Rube Goldberg: Inventions* by Maynard Frank Wolfe and Rube Goldberg. Simon & Schuster, 2000.
- Physics 98 Institute lesson plans website: http://www.owu.edu/~mggrote/phys98/lessons.html
- Rutgers University Physics Education Resource website: http://www.physics.rutgers.edu/hex/visit/lesson/lesson_index.html
- The Physics Classroom lessons website: http://www.glenbrook.k12.il.us/gbssci/phys/Class/energy/energtoc.html

Pre- and post activities/handouts:

- One possible pre activity: Have students create their own toys or improve upon an old favorite. Bring these toys to class to begin the conversation about potential and kinetic energy.
- Post activity: Create a more elaborate Ball Machine toy (using whatever supplies are available to the students) and market it (create packaging, advertisements, commercials, etc).
- Post-activity: Hold a Rube Goldberg Machine contest for the class. See the official website: http://www.rube-goldberg.com