

The Canada Science and Technology Museum
presents

The Science of Sports

Section 4 Energy



CANADA SCIENCE AND
TECHNOLOGY MUSEUM

Canada 

Introduction





Energy, or the ability to do work, is an essential concept in understanding sports. It is not only an important consideration when deciding how to power the next big stadium, but also when deciding what food to eat right before a tournament, or how hard to kick a soccer ball to complete a pass.

In this section, students will explore different forms of energy, and will learn how and why energy is transformed from one form to another. Through experiments, students will observe that energy transformation is not a completely efficient process, and that some energy will always be transformed into a less desirable form. Students will learn that energy cannot be created or destroyed—it can only be transformed.

This section contains the following components:

- 4.1. Forms of Energy
- 4.2. Energy Transformation

Distinctive icons throughout the exploration guide indicate key features, helping you to navigate your way through the text quickly and efficiently.

 Classroom Activity	 Discussion or Assignment Topic
 Deeper Study	 Website to Visit

Activity Resources

Many of the following activities require students to conduct research online. Worksheets for all activities are included at the end of this section. Teachers may request an answer package for the more complex activity sheets by e-mailing **virt_prog@technomuses.ca**. Please allow one to two weeks for a reply.

Activities

Activity 4.1. Forms of Energy (Suitable for Grades 4 to 7)



Energy is the ability to do work. The term work is defined as a force, acting over a certain distance. It can manifest itself in various forms— heat energy from the Sun, warming our atmosphere and creating wind; chemical energy stored in a battery that powers a pacemaker; or light energy that allows plants to grow. By investigating sports and physical activity, students will explore the various forms that energy can take.

For more information on energy, please visit the following website:

http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Energy.cfm



Classroom Discussion: Ask students what they think energy is. Write their ideas on the board, and direct them to the conclusion that energy is the ability to exert a force over a distance. Ask students if they can name different forms of energy. Write these on the board as well. Make sure that they provide examples of each form.



For example:

Potential Energy: Energy that can be stored in order to do work at a later time. For example, if a ball is lifted off the ground, it has potential energy. Gravity is an example of potential energy (called “gravitational potential”).

Kinetic Energy: The energy of motion. The faster an object moves, the more kinetic energy it is said to possess.

Chemical Energy: Energy derived from a chemical reaction (for example, the food we eat undergoes a chemical reaction to provide our bodies with heat, nutrients, etc.).

Muscular Energy: Our muscles can move thanks to the energy stored in them.

Light Energy: Plants can use this energy due to a process called photosynthesis.

Electrical Energy: This is the movement of charges, such as the movement of electrons inside a copper wire.

Deeper Study (for older students):

Other forms of energy could also be discussed. For example, solar, thermal (heat radiation), nuclear, wind, water and fossil fuels are sources of energy that we often consider when discussing how to power our cities, houses or cars.



These sources of energy are an important consideration when planning large sporting events such as the 2010 Vancouver Olympic Games. Athletes from all over the world lived in the Olympic Village for the duration of the Games. The Vancouver Olympic Village was built with energy efficiency in mind. For example, heat from sewer lines was captured and used in close proximity to its source, in order to heat buildings and tap water.

To learn more about energy use at the Olympic Village, please visit the following websites:

www.thechallengeseries.ca/chapter-05



Students can also research the type of energy-saving initiatives undertaken at major sport stadiums. This information can be found on a resident sports team's corporate website, such as these:

<http://www.theaircanadacentre.com/about/GreeningMLSE.asp>

<http://canadiens.nhl.com/club/page.htm?id=66762>

Please note that not all professional sports teams publish this information.

Name: _____

Chemical Energy Log
Activity A.L.: Part 1

	Breakfast	Snack	Lunch	Snack	Dinner
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					

Part 1: Chemical Energy

Objective: To identify food as a source of chemical energy, necessary for animal life.

Chemical energy is found in the bonds between the atoms that form a molecule. We store this kind of energy inside our bodies, and use it when we move or exercise. Animals acquire chemical energy through the foods they eat. Energy can be derived from molecules such as the carbohydrates found in fruit, bread, pasta, beans, potatoes, grains and cereal. Fat molecules that are ingested can be stored in our bodies as a long-term energy source. When the body needs to use these molecules, it converts them into sugars that can be used by the muscles. Proteins are also found in our diet; although they are usually used as building blocks for muscles and organs, they can also be converted into sugars and used as a source of energy, if needed.

1. Ask students where they get their chemical energy by instructing them to fill out a log listing the food that they consume in a week. They can complete the activity sheet as the week goes by, and analyze it the following Monday.

Afterwards, ask students what they think about their eating habits. Are they healthy? Is anything missing from their diet?

2. Ask students to build their own food guide in order to improve their eating habits. It is possible to create a personalized food guide at the following website:

<http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/myguide-monguide/index-eng.php>



NAME: _____

Chemical Energy Log
Activity 4.1.1, Page 2

For each food item eaten in one day, fill out a row in the table below.

Food	Portion size in grams (must be at least 100g)	Calories per portion (from the information on the label)	Total amount of calories ingested from this food (Calories per portion x portion size)

Most food items that are bought at a grocery store are labelled with nutritional information. These labels contain information about the Calories (the energy) contained in one portion of a particular food. The size of the portion is indicated on the label. Ask students to calculate how many calories they consume in one day. This is an activity best done on a weekend, when students will be able to look at the labels on each product they consume. Enlisting the help of the parents would be a good idea, as some nutritional information labels are difficult to read or even find.

3. Have each student fill out the activity sheet and make a list of everything that was consumed in one day. This list should include portion size, calories per portion, and the total amount of calories ingested from each food item.

Although it might seem interesting to do a comparison of each student's caloric intake during one day, please bear in mind that this may be a sensitive subject for many students in your class. The goal of the exercise is simply to understand that animals (humans) get energy from food, and that different food items provide us with different amounts of energy.

Alternatively, each student can do this analysis with one pre-packaged snack that they bring to school.

Background Information: calories vs. Calories

The calorie is a measure of energy. There are two different kinds of calories: small calories (cal) with a lowercase "c" and large Calories (Cal) with an uppercase "C" (also known as kilocalories or Kcal). Small calories represent the energy needed to heat 1 gram of water by 1 degree Celsius, or approximately 4.2 Joules (Joules are another unit of energy). Large Calories are equal to 1,000 small calories, or 4.2 Kilojoules. When talking about the energy content of food, it is more useful to use large Calories (or Kilocalories) or Kilojoules—this is the measurement used on nutritional information labels.

Part 2: Potential and Kinetic Energy

Objective: To understand the difference between potential and kinetic energy.

Concepts

Potential energy is the energy stored in an object. In other words, it is the capacity to do work at a later time. For example, if you lift a ball off the ground, it has the potential to fall. The higher the ball is off the ground, the more potential energy it has. As the ball falls to the ground, its potential energy decreases.

Kinetic energy is the energy an object has when it is in motion. The faster the object travels, the more kinetic energy it has.

When a ball is held in the air, it is not moving, and has no kinetic energy; but it does have a lot of potential energy. As the ball falls to the ground, the kinetic energy increases as the speed of the ball increases, but the potential energy decreases.

Classroom Demonstration: Take a tennis ball and raise it above your head. Ask students if the ball is moving. No—so it does not have any kinetic energy. Ask students if the ball has the potential to move. It has—towards the ground. The ball thus has potential energy.



Just before the ball hits the ground, it will be moving very fast, which means it has a lot of kinetic energy. However, since it is so close to the ground, it will not have much potential energy.

To demonstrate this further, you can organize a game of volleyball. You can explain that, when a player sets the ball or makes a pass, the ball is propelled through the air in an arched trajectory. The ball is said to possess kinetic energy because it is in motion. However, whenever the ball is thrown in the air either straight up, or following an arched trajectory, there is a very brief moment just after the ball stops travelling upwards—but before it starts falling back to the ground—when the ball possesses very little vertical kinetic energy, but a lot of potential energy.

This discussion is only an introduction to the concept of potential and kinetic energy. Your class will have a chance to explore the transfer of potential and kinetic energy with hands-on activities in the next section.

Name: _____

Forms of Energy
Activity A.1: Part 3

Choose a technique from your favorite sport and analyze the forms of energy needed to perform the technique.

Example: To swing a baseball bat

- 1) Chemical Energy: the food the player has eaten, and the oxygen he/she has inhaled allow him/her to have energy to play.
- 2) Muscular Energy: the energy from the feet is used by the muscles to move the bat behind the player's body as he/she is standing at the plate, ready to swing.
- 3) Potential Energy: stored in the bat as it is held above the height at which it makes contact with the ball.
- 4) Kinetic Energy: the bat is in motion as the player swings it around his body in order to hit the ball.
- 5) Sound Energy: produced when the bat makes contact with the ball.

Your turn!

Sport: _____

Technique: _____

Form of energy:

- 1) _____
- 2) _____
- 3) _____

Part 3: Energy in Sports

Objective: To understand that any movement is a combination of different forms of energy.

Have students pick a specific technique in the sport of their choice. Ask them to analyze the technique and report on the different forms of energy needed to successfully perform the technique.

Examples of techniques include:

- Baseball pitch
- Slapshot
- Tennis backhand
- Volleyball spike
- 3-metre dive

An example of this is provided on the activity sheet.

Take your students to the gym and have them try a few techniques, analyzing the different forms of energy at work. You can ask students to research the techniques online, perhaps starting with the following websites:

<http://www.olympic.org/sports>

<http://www.olympic.ca/en/sports/>

<http://www.pch.gc.ca/pgm/sc/fed/index-eng.cfm>



Activity 4.2. Energy Transformation

(Suitable for Grades 4 to 7)



Energy can be transformed from one form to another, but it can never be lost. If a battery is linked to a light bulb with copper wires, the light bulb will light up. In this simple example, the chemical energy stored in the battery is transformed into electrical energy, which travels through the wires to the bulb where it was transformed again into light and heat energy. Energy is sometimes transformed into less-desirable forms, such as heat in the case of a light bulb. By using a more efficient light bulb, more electrical energy will be converted into light, and less into heat.

These concepts also apply to sports. In this section, students will learn about energy transfer by observing and measuring the bounces of various balls, and by determining how different materials can affect the efficiency of energy transfer.

For more information about energy transformation, please visit the following websites:

http://www.sciencetech.technomuses.ca/english/schoolzone/Info_Energy.cfm



Name: _____

Energy Transformation
Activity 4.2 Part 1

In teams of two: pick one person from your team to hold a tennis ball 2 metres off the ground, while also holding a measuring tape. The measuring tape's "0" should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Initial Height: _____

Form of energy present before the ball is dropped: _____

Form of energy present just before the ball hits the ground: _____

Trial	Height in metres of the first bounce
1	
2	
3	
4	

Part 1: Energy Transformation Efficiency

Objective: To observe that energy transformation is almost never 100% efficient.

Bring students outside, or into the gymnasium. Give each team of two students the following:

- A tennis ball
 - A measuring tape (at least 2 metres in length)
1. Ask one student to stand on a chair and hold the ball 2 metres from the ground. That same student will hold a measuring tape next to the ball. The tape should be long enough to touch the ground.
 2. Have the other student stand next to their classmate, and measure how high the ball bounces after it hits the floor.
 3. Students should try this 3 or 4 times, and record their findings on the activity sheet.

After the activity, discuss with students why the ball did not bounce back to its original height of two metres. Ask them to speculate how this energy was lost, and what type of energy it was transformed into.

When the ball is held two metres above the ground, it does not have any kinetic energy (it is not moving), but it does have potential energy (stored energy). When the ball is let go, the potential energy is transformed into kinetic energy. When the ball hits the ground, it gets slightly squished and deformed. It thus acquires another form of potential energy, called elastic potential energy, as the rubber from the ball tries to regain its original shape. This is equivalent to pushing down on a spring. As soon as the spring is released, it will regain its original shape.

The fact that the rubber molecules rub against one another during this squishing phase causes friction between them. This causes the ball to heat up, meaning that some of the energy has been transformed into thermal energy. This is one of the reasons why the ball will not bounce back up to its original height, and why a ball that is bounced frequently will feel slightly warm.

The sound that is heard when a ball bounces is also due to energy transformation—the kinetic energy of the ball is transformed into sound energy when the ball hits the ground.

Name: _____

Energy Transformation
Activity A.2: Part 2

In teams of two: pick one person from your team to hold a tennis ball 2 metres off the ground while also holding a measuring tape. The measuring tape's "0" should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Trial	Weight of ball	Type of ball	Height of bounce in metres
1			
2			
3			
4			
5			
6			
7			
8			

Part 2: Influence of Materials on Energy Transfer

Objective: To observe that material composition will influence how well energy is transferred.

Have students repeat the same experiment, but with different kinds of balls. Have them record their findings on the activity sheet.

After the activity, discuss the influence that the different ball materials had on the height of the rebound.

Many balls are made of molecule chains called polymers. When the ball hits the ground, the molecules get squished and deformed. Some molecules are very quick to regain their original shapes, while others are not. It is the elastic properties of the molecule chains that determine whether or not a ball will be 'bouncy.'

Note: Temperature affect the way that molecules regain their original shape after being squished. Try freezing a tennis ball, and compare its bounce to that of a room-temperature ball.

Classroom Discussion: Using a relatively accurate infrared thermometer (a reasonably-priced tool available at most hardware stores), ask students to take the temperature of the ball before bouncing it, and again after bouncing it for a few minutes. Students will find that the temperature has increased—a sign that energy has been lost in the form of heat.



Name: _____

Energy Transformation
Activity 4.2, Part 3

Follow the instructions below to calculate a ball's potential and kinetic energy.

To make your calculations, you will need:

- Mass of each ball in kilograms
- Height at which the balls are dropped in meters
- Acceleration of free-falling objects due to gravity = 9.8 m/s^2 (This does not change)
- Initial speed of the ball = 0 m/s (the ball is at rest)

Potential Energy
Use the formula below to calculate the potential energy:
 $Potential\ energy = mass \times height \times acceleration$

Kinetic Energy
To calculate the kinetic energy of the ball, you will first need to calculate the final speed of the ball, right before it hits the ground. Here is how you do it:

$$Final\ speed = \sqrt{(Initial\ speed)^2 + 2 \times (acceleration \times height)}$$

Step 1: Calculate all the values inside the parentheses

a) Initial speed \times initial speed = _____

b) Acceleration \times height = _____ Multiply this value by 2: _____

Step 2: Add the two values obtained in Step 1.

Step 3: With a calculator, find the square-root of the value obtained in Step 2.

Part 3: Potential and Kinetic Energy (Grade 7)

Objectives: To understand the difference between potential and kinetic energy. To observe the transformation between the two forms. To introduce mathematical equations for the calculation of kinetic and potential energy.

Have students calculate each ball's potential energy before it begins to fall to the ground, and each ball's kinetic energy right before it hits the ground. Students will realize that the potential energy before the ball falls is equal to the kinetic energy right before the ball hits the ground.

This activity will allow students to visualize how energy is transformed.

Group Assignment: Building an Energy-Transforming Device

Motorsports are events and competitions that involve motorized vehicles such as car racing, motorcycle racing, air racing (airplane racing), boat racing or even lawnmower racing. Although the success of the participants is not necessarily dependent on their physical fitness, as in more traditional sports, their understanding of energy transformation is just as important.



In an internal combustion engine, the chemical energy stored in the gasoline and the oxygen will, after being ignited, release thermal energy (heat). This thermal energy will expand the gases within the cylinders and apply pressure to the pistons, moving them over a certain distance. The pistons will therefore have kinetic energy. This kinetic energy is then transferred to various parts of the vehicle.

Ask your students to design, build and test a device that transforms one form of energy into another. Have them work in groups of 3 or 4. You can ask the whole class to build the same device, or ask each group to choose the device they would like to build.

Here are two examples. These websites include instructions and lists of materials.

Elastic Powered Car:

<http://www.sciencetech.technomuses.ca/english/schoolzone/try-this-out-intense-science.cfm>

Magnet-Powered Car:

<http://www.sciencetech.technomuses.ca/english/schoolzone/try-this-out-magnet-mobile.cfm>



Deeper Study: Electrical Signals in the Human Body (Suitable for Grade 6 and 7)

Electrical energy is not only found in lightning and circuits; it can also be found in the bodies of animals such as humans.



A group of cells in the heart is responsible for creating electrical impulses that maintain the steady rhythm of our heartbeats. We can measure the electrical activity in our heart with a device called an electrocardiograph (also known as an ECG or EKG).

Students can research topics related to irregular heartbeat, such as:

- The pacemaker: a medical device that delivers electrical pulses to heart muscles in order to regulate the heartbeat.
- Arrhythmia: a broad medical condition in which the heart's natural electrical pulses are abnormal, causing an abnormal heartbeat.
- Tachycardia: a type of arrhythmia in which the heart beats too fast.
- Bradycardia: a type of arrhythmia in which the heart beats too slowly.
- Electrocardiograph: a device that measures the electrical activity in the heart.

Students can start their research at this website:

Heart an Stroke Foundation

<http://www.heartandstroke.com/site/c.ikIQLcMWJtE/b.3484057/k.22A1/Arrhythmia.htm>



Name: _____

Chemical Energy Log

Activity 4.1.: Part 1

	Breakfast	Snack	Lunch	Snack	Dinner
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					



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Name: _____

Chemical Energy Log

Activity 4.1.: Part 2

For each food item eaten in one day, fill out a row in the table below.

Food	Portion size in grams (this can be an approximation)	Calories per portion (find this information on the label)	Total amount of calories ingested from this food item (portion size x Calories per portion)
Example: 2 Caramel chocolate bars	56 g	273.28 Cal for 56 g	(2 X 273.28) 556.56 Cal



Name: _____

Forms of Energy

Activity 4.1.: Part 3

Choose a technique from your favourite sport and analyze the forms of energy needed to perform that technique.

Example: Swinging a baseball bat

- 1) Chemical Energy: the food that the player has eaten, and the oxygen they have inhaled allows them to have energy to play.
- 2) Muscular Energy: the energy from the food is used by the muscles to move the bat behind the player's body as they are standing at the plate, ready to swing.
- 3) Potential Energy: stored in the bat as it is held above the height at which it will make contact with the ball.
- 4) Kinetic Energy: the bat is in motion as the player swings it around his body in order to hit the ball.
- 5) Sound Energy: produced when the bat makes contact with the ball.

Your turn!

Sport: _____

Technique: _____

Form of energy:

1) _____

2) _____

3) _____



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Name: _____

Energy Transformation

Activity 4.2.: Part 1

Form a team of two. Pick one person from your team to hold a tennis ball 2 metres off the ground, while also holding a measuring tape. The measuring tape's '0' should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Initial Height: _____

Form of energy present before the ball is dropped:

Form of energy present just before the ball hits the ground:

Trial	Height in metres of the first bounce
1	
2	
3	
4	



Name: _____

Energy Transformation

Activity 4.2.: Part 2

Form a team of two. Pick one person from your team to hold a tennis ball 2 metres off the ground, while also holding a measuring tape. The measuring tape's '0' should be just above the ground. When the ball is dropped, the other person will record the height of the first bounce.

Trial	Type of ball	Height of bounce in metres
1		
2		
1		
2		
1		
2		
1		
2		



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Name: _____

Energy Transformation

Activity 4.2.: Part 3

Follow the instructions below to calculate a ball's potential and kinetic energy.

To make your calculations, you will need:

- Mass of each ball in kilograms
- Height from which the balls are dropped in metres
- Acceleration of free-falling objects due to gravity = 9.8m/s^2
(This does not change)
- Initial speed of the ball = 0 m/s (the ball is at rest)

Potential Energy

Use the formula below to calculate the potential energy:

$$\text{Potential energy} = \text{mass} * \text{height} * \text{acceleration}$$

Kinetic Energy

To calculate the kinetic energy of the ball, you will first need to calculate the final speed of the ball, right before it hits the ground. Here is how you do it:

$$\text{Final speed} = \sqrt{(\text{initial speed} * \text{initial speed}) + 2 * (\text{acceleration} * \text{height})}$$

Step 1: Calculate all the values inside the parentheses

a) Initial speed x initial speed = _____

b) Acceleration x Height = _____ Multiply this value by 2: _____



Step 2: Add the two values obtained in Step 1.

Step 3: With a calculator, find the square root of the value obtained in Step 2.

The answer for Step 3 will give you the final speed of the ball.
To calculate the kinetic energy, use the following formula:

$$\text{Kinetic energy} = \frac{1}{2} * \text{mass} * \text{final speed} * \text{final speed}$$

OR

$$\text{Kinetic energy} = \frac{\text{mass} * \text{final speed} * \text{final speed}}{2}$$

Type of ball	Mass	Height	Potential energy	Final Speed	Kinetic energy

Compare the potential energy before the fall, and the kinetic energy at the end of the fall. What do you notice?



Calculate the kinetic energy of a ball at rest (The final speed is equal to zero, because the ball is not moving). To calculate this, use the formula below.

$$\text{Kinetic energy} = \frac{1}{2} * \text{mass} * \text{final speed} * \text{final speed}$$

Calculate the potential energy of the ball right before it hits the ground (the height will be equal to zero). To calculate this, use the formula below.

$$\text{Potential energy} = \text{mass} * \text{height} * \text{acceleration}$$

In this diagram, insert the correct amount of potential energy and kinetic energy at each stage of the fall. Use the values you have calculated for the tennis ball in the above exercises.

