Science Unit: **Force, Energy Transfer and Machines**

Lesson #1: ***Hot Wheels – Energy Transfer***

Lesson Summary

Students conduct an experiment to test two research questions related to **energy transfer**. Using *Hot Wheels* cars on a track, students test how increased **potential energy** (height of release) and increased **friction** (salt on the track) affect the **kinetic energy** (distance traveled) of the cars. They **collect data** to test their ideas, repeating each test three times and **calculating the average**.

Developed by:	Dominic Tollit (scientist); Marielle Weisinger and Atsuko Fairweather (teachers)
Grade level:	Presented to grades 4-5, suitable for grades 4-7 with modifications
Duration of lesson:	1 hour and 20 minutes
School Year:	2016/2017
Developed for:	Cunningham Elementary School, Vancouver School District
Notes:	This lesson links with two more lesson on force and energy transfer

Objectives (Objectives refer to the science topic and/or the process of science.)

a) Learn about energy conservation and transfer (potential energy to kinetic energy and then heat energy via friction) using hot wheel cars speeding down a hot wheel track.

b) Students will design their own experiment to test a research question related to energy transfer. Options to test:

   i) distance travelled depending on height of track at start, i.e., increase potential energy

   ii) distance travelled when friction is applied (application of salt on the track) thereby increasing speed of transfer to heat energy and sound

   iii) distance travelled when additional energy is applied (through use of launchers)

c) Discuss conservation of energy and how energy transforms from one energy state to another.

Background Information

Energy makes things happen – it's in sunlight, waves, wind, cars, humans, everything. Energy helps us do things – it runs machines, it makes things move, energy is light and heat, energy can male things grow. Our tides are caused by the gravity of the sun and moon and we are starting to make renewable (replaceable) energy from the tides (note link with lesson 2 –tidal turbines). Energy can be transferred (change from one form to another) but it can NOT be created nor destroyed. This is called the Universal Law of the Conservation of Energy.

Work or force cannot be done without energy. When work is done - energy is used and transformed into another or even multiple forms of other energy. Like food into running or walking (movement) as well as into heat (sweating) and sound (footsteps), fuel burnt for cars to move or making electrical energy for light and power. Much energy comes from the sun to begin with (e.g., oil, coal, our food crops via photosynthesis) but there are also other sources – like nuclear energy. The different forms of energy include chemical (from food), movement energy called kinetic energy and a special energy you can't see – called potential energy. This is the energy stored by an object – either through its position relative to the earth's gravitational force field or by tightening an elastic band or a spring release!

Vocabulary

Potential energy: Stored energy. Different forms include elastic (rubber bands, springs, a bow), electric fields and position within the Earth's gravity field. For example, lifting an object up higher into the air.

Kinetic Energy: Energy based on movement of an object (e.g., Throwing a ball, car racing down a track)

Friction: Resistance to movement of an object. Friction causes heat energy (e.g., Rubbing your hands together, car tires on a road)

Materials

- 6 Hot Wheels cars
- 20-30m of Hot Wheel tracks
- 3 spring release Hot Wheel firers
- 6 10m tape measures
- Masking tape
- Box of salt
- Stacks of books

In the Classroom

Introductory Discussion

1. Short description of 'hook' to capture student's attention.
    - **What can we not live without or move without?**

      Energy. Energy makes things happen – it's in sunlight, waves, wind, cars, humans, everything. Today we are going to learn about one of the Universes' most important laws. That energy is conserved or maintained. It can be transferred from one form to another but not destroyed.
    - Work or force cannot be done without energy. When work is done - energy is used and transformed into another or even multiple forms of other energy. Like food into running or walking (movement) as well as into heat (sweating) and sound (footsteps), fuel burnt for cars to move or making electrical energy for light and power. Much energy comes from the sun to begin with (e.g., oil, coal, our food crops via photosynthesis) but there are also other sources – like nuclear energy. So energy helps us do things – it runs machines, it makes things move, energy is light and heat, energy can male things grow. Our tides are caused by the gravity of the sun and moon and we are starting to make renewable (replaceable) energy from the tides
    - So if you can't create energy – where does the energy come from for us to send a car down a hot wheels track? Take answers from students. Build towards correct answer. Sun (it all starts with the suns energy) – through Plants – often through Animals to human food (which in our body can be called Chemical energy, then into movement energy called Kinetic energy and a special energy you can't see – but it's called Potential energy. This is the energy stored by an object – either through its position relative to the earth's gravitational force field or by tightening an elastic band or a spring release!

2. Explain to students to do a proper science experiment we need to do 5 things.
    1) Ask a question or make a prediction (**HYPOTHESIS**)
    2) Develop a plan or **EXPERIMENTAL METHOD** to test this question or hypothesis. Make sure it is repeatable!
    3) Conduct the experiment and carefully **RECORD DATA**. Identify any problems encountered.
    4) **ANALYZE** data to check if it supports or does not support your hypothesis.
    5) Make a **CONCLUSION** or inference based on the results.

    Explain that we are going to carry out all these steps today – while testing an important law of the universe!
3. Briefly describe science experiment/activity:

    We are going to do an experiment with Hot Wheels cars that shows us the transfer of energy from kinetic (our muscles moving) to potential (lifting up an object higher or using a spring release) to kinetic energy (the car going down the tracks), then changing into heat energy (friction between the car wheels and the track – get students to rub hands together to explain this concept) and sound energy (clapping).

4. Processes of science:

    This lesson includes making predictions, planning and conducting an experiment and observing and making measurements, collecting data and making conclusions.

5. Safety guidelines:
    - Careful with the tape measures and the release button
    - Don't throw salt around

Science Activity/Experiment

Hot Wheels – Energy Transfer Activity

Purpose of Experiment:

Based on what we know about energy, we plan to test two predictions.

a) A car that is placed on a track higher than another car will travel further along the track

b) A car travelling on a track covered with salt travel will not travel as far as one without salt on the track

(Optional) c) A car that released with additional potential energy will travel further than one that is not

Methods:

1. Students are separated into groups of 4-5. Each is provided with car, track, tape measure, tape and stack of books. Scientist will provide salt needed when experiment (a) is completed, and spring release firer if time permits. Show students that tape measure has cm and inches marked and which to use.

2. Experiment (a) involves taping hot wheels track to a surface 40cm high (on stack of books), position a car on the edge of the slope and release car. Measure the distance travelled in cm after 3 releases. Record on data sheet. Repeat after lowering the track to 20 cm (on stack of books). Measure distance travelled after 3 releases. Record on data sheet. Calculate average with calculator. Determine which height the car travelled further on (high or low height). Students to make conclusion based on their knowledge of how energy is being transferred using data sheet provided.

   Teachers' notes: The car placed higher has been given more potential energy. This energy is transferred into kinetic energy on release. As energy is conserved this means the higher car will travel further before energy is changed into heat energy (friction between track and wheels) and sound energy.

3. Check that students measure in cm (not inches) on the tape measures and that the tape is positioned from the start on each release and is straight along the track. Highlight if cars bump into anything or are pushed, then the launch should be repeated and the "bad" data not recorded. Make sure students are writing down correct distance to where the car ends up.

4. Experiment (b) involves using the same hot wheels track at 20 cm high (stack of books) but adding a good dusting of salt to 1-2 m of flat track. Measure new distance travelled after 3 releases and record on data sheet or use distance data from experiment (a). Record on data sheet. Determine which travelled further – with salt or without salt. Make Conclusion based on how energy is being transferred.

   Teachers' notes: In both tests, both cars are given the same amount of potential energy. The salt increases the friction on the track so energy is lost quicker as heat energy – this faster change from kinetic energy to heat energy results in the car with salt on the track not travelling as far - salt increases friction between track and wheels. Small increase in sound energy transfer also.

5. Experiment (c) involves using the same hot wheels track at 20 cm high (stack of books), but releasing the car using a spring release firer connection. Measure distance in cm travelled after 3 releases. Record on data sheet. Determine which travelled further – car with firer or without firer. Make Conclusion based on how energy is being transferred.

   Teachers' notes: The car fired using the spring release has both potential energy from its height AND lots of potential energy from the spring. The additional energy from the spring will mean the car travels further down the track.

6. See student data sheet and worksheet below. Students can use a calculator to generate an average. Ensure they remember to add all three values and divide by three to get an average.

Closure Discussion

- Review which of the predictions were confirmed (hopefully all of them)
- Remind students about the 'Conservation of Energy'
- Discuss variables – letting the car go rather than pushing it, amount of salt used
- Discuss how we undertook a "real science experiment" and review the 5 steps

Extension of Lesson Plan

1. Test different weights of cars.
2. Olive oil on the track to reduce friction.

Hot Wheels Data Sheet
Energy Transfer
(fill in grey area using tape measure)

Name(s):

Date:

Experiment description	Car launch number	Distance in cm travelled
Car released at 40 cm height	First launch:	
Car released at 40 cm height	Second launch:	
Car released at 40 cm height	Third launch;	
Car released at 40 cm height (experiment a)	All three launches	**Average distance:**
Car released at 20 cm height	First launch:	
Car released at 20 cm height	Second launch:	
Car released at 20 cm height	Third launch;	
Car released at 20 cm height (experiments a, b and c)	All three launches	**Average distance:**
Car released at 20 cm height + salt on track	First launch:	
Car released at 20 cm height + salt on track	Second launch:	
Car released at 20 cm height + salt on track	Third launch;	
Car released at 20 cm height + salt on track (experiment b)	All three launches	**Average distance:**
Car released at 20 cm height + spring release	First launch:	
Car released at 20 cm height + spring release	Second launch:	
Car released at 20 cm height + spring release	Third launch;	
Car released at 20 cm height + spring release (experiment c)	All three launches	**Average distance:**

How to Calculate the Average Distance

The average for 3 repeated measurements (All) is calculated as (A + B + C) ÷ 3.
For example, if the car travelled 3m, 5m, and 4m.

Step 1:	Put distances in the equation.	(A=3, B=5, C=4)
Step 2:	Add A, B and C together.	(3 + 5 + 4) = (12)
Step 3:	Divide that number by 3.	(12) ÷ 3 = 4
Step 4:	Add the units.	4 *metres*
Answer:	Average = 4 m	

CONCLUSIONS

(based on data sheet results and definitions provided)

Experiment a) one car placed higher than the other (from 40cm versus from 20 cm height)
Which car travelled
further? .....
Why did this car travel further? Use knowledge of energy transfer to explain your observation.

Experiment b) salt on the track added compared with no salt (both from 20cm height)
Which car travelled the least
distance?.....
Why did this car travel less far? Use knowledge of energy transfer to explain your observation.

OPTIONAL Experiment c) spring release (extra energy) **added** (not just releasing the car)
Which car travelled the furthest
distance?.....
Why did this car travel further? Use knowledge of energy transfer to explain your observation.