SCIENCE NORTH SCIENCE NORD
SUDBURY, ONTARIO, CANADA

Friction **Grade 12 – Mechanical Systems**

Lesson Plan

Assessment	AFL, AOL
Cross-curricular	

Big Ideas

- Mechanical systems use force to do work.
- The operation of mechanical systems can be described using mathematical relationships.
- Friction is a force that influences the design, use, and effectiveness of mechanical systems.

Learning Goals

- I can define friction and explain its causes.
- I can define the normal force, static friction, kinetic friction, and coefficient of friction.
- I can describe the factors affecting static and kinetic friction.

Specific Expectations:

A1. demonstrate scientific investigation skills (related to both inquiry and research) in the four areas of skills (initiating and planning, performing and recording, analysing and interpreting, and communicating);

A1.5 conduct inquiries, controlling relevant variables, adapting or extending procedures as required, and using appropriate materials and equipment safely, accurately, and effectively, to collect observations and data

C2. investigate forces, torque, work, coefficients of friction, simple machines, and mechanical advantage, and interpret related data;

C2.1 use appropriate terminology related to mechanical systems, including, but not limited to: coefficients of friction, torque, mechanical advantage, work input, and work output

C2.3 use an inquiry process to determine the factors affecting static and kinetic friction, and to determine the corresponding coefficient of friction between an everyday object and the surface with which it is in contact infection of the skin, treated with fungicides)

Description:

In this lesson students will do an experiment that moves a box along a horizontal plane and on a ramp to learn about the factors affecting static and kinetic friction. This activity should occur after students have learned Newton's Laws and been introduced to free-body diagrams. **This lesson is intended for the college level**.

Materials

Mythbusters video
How to Start a Friction Fire Using Hand Drill in Under 1 Minute video
Fiction Facts (Student and Teacher)
Coefficient of Static Friction (Student and Teacher)
Coefficient of Static Friction Data Sheet (Student)
Coefficient of Static Friction Activity

Group Materials

- 1 m fishing line
- Small cardboard boxes of varying sizes (i.e. 10 cm x 10 cm x 10 cm or 12 cm x 12 cm x 12 cm)
- 1.2 m ramp
- Stopwatch
- Various masses
- Small wicker or plastic basket with a handle
- Desk or table

Scale
Tape

Additional Materials:

- Wax paper
- Several grids of sandpaper
- Felt
- Aluminum Foil
- Different types of cardboard
- Talcum powder
- Water
- Oil

Exit Card (Student and Teacher)

Safety Notes

No safety issues with this lesson plan.

Introduction

First, watch this clip from Mythbusters.
https://www.youtube.com/watch?feature=player_embedded&v=hOt-D_ee-JE
Kigents
Uploaded September 18, 2008
Retrieved February 21, 2016

In learning to draw free-body diagrams, students have already come across a "force of friction" which generally opposes the applied force acting on an object. In fact, friction is not a fundamental force such as gravity, the electromagnetic force, the strong force, or the weak force, but rather, a result of the forces between the surface characteristics of two surfaces such as roughness or adhesion. ***Friction*** is a "force" which opposes ***any*** relative motion of two touching surfaces. ***Static friction***, or the force which prevents you from getting objects moving (as in the above, telephone book example) is greater than ***kinetic friction***, or the force which resists movement once an object is in motion.

This opposing force can be "dry friction" between lateral solid surfaces or "fluid friction" between fluid surfaces (i.e. viscosity), "skin friction" between a body and fluid (as in the case of "drag"), and even "internal friction" within objects being deformed (stretched or squashed) as the forces between their composite elements resist movement. Friction results in the *transfer of kinetic energy to thermal energy*, or heat.

This friction can be useful – i.e. if you're ever lost in the woods:
How to Start a Friction Fire Using Hand Drill in Under 1 Minute (See Materials/Resources Section)
https://www.youtube.com/watch?v=RWLz1L52-hQ
Zardz
Uploaded Sept. 22, 2008
Retrieved February 21, 2016

Friction is also required in order to walk (which is impossible on a frictionless surface) or write (a result of the friction of the ballpoint on the paper and your hand gripping the pen), or come to a complete stop on your bicycle (which happens due to the friction of the brake pads acting on the wheels).

However, friction can cause wear on mechanical systems requiring the regular inspection and replacement of parts (such as brake pads or gears) and even potentially causing disaster as in the Colombia space shuttle explosion in 2003 when the friction of the atmosphere against the shuttle caused it to ignite upon re-entry.

Using the Internet, students complete the note: "Friction Facts" (see Link)

Action

Coefficient of Static Friction Activity (See Link)

In this activity, students will explore factors potentially affecting the coefficient of static friction: surface area, mass, and surface material.

Students develop an experiment to explore the factors affecting the coefficient of static friction: surface area, mass, and surface material. There are two (or more) possible methods to perform this experiment. In the first, a box is pulled across a horizontal surface using the force of gravity acting on an attached basket. In the second, a ramp is lifted until the point where a box starts moving.
In groups of three, students should be encouraged to also come up with another, more innovative, method to determine the coefficient of friction.

Group Materials

- 1 m fishing line
- Small cardboard boxes of varying sizes (i.e. 10 cm x 10 cm x 10 cm or 12 cm x 12 cm x 12 cm)
- 1.2 m ramp
- Stop watch
- Various masses
- Small wicker or plastic basket with a handle
- Desk or table
- Scale
- Tape

Additional Materials:

- Wax paper
- Several grids of sandpaper
- Felt
- Aluminum Foil
- Different types of cardboard
- Talcum powder
- Water
- Oil

Option A: Box and Basket Instructions

1. Record the masses of the box and the basket (in kg).
2. Tie the fishing line around perimeter of the box and tape it around the box.
3. Once in place, tape the line in place so that it does not slip off or shift during testing.
4. Attach the other end of the line to the basket handle and hang the basket off the edge of a desk/table while placing the box in the center of a desk/table.
5. Place a mass (~500 g) in the box, and slowly and gently add masses, in 5-10 g increments, to the basket until the box just begins to slide.
6. Record the total mass in the basket that finally caused the box to begin sliding.

Option B: Ramp Instructions

1. Create a ramp using some books or other objects to make a "rise". Mark the starting point with tape or a marker.
2. Place a mass (~500 g) in the box near the top of the ramp and gradually raise the end of the ramp until the box begins to slide down. Repeat this step 2 or 3 times.
3. Use a metre stick or tape measure to measure the "rise" and "run" of the ramp.
4. Record the "rise" and "run" of the ramp.

Analysis

A. Draw free-body diagrams of the box and basket.
B. Use the Coefficient of Friction Data Sheet to record data and then calculate the coefficient of friction for each trial.
C. Why use fishing line instead of string or thread for this experiment?
D. How is the coefficient of friction affected by changing the mass in the box?
E. How is the coefficient of friction affected by changing the material under the box?
F. How is the coefficient of friction affected by changing the size of the box?
G. Why can you not use the same calculations to determine both the static and kinetic coefficients of friction?
H. List at least one other way in which to reduce the coefficient of static friction?
I. Name at least 2 sources of experimental error in this experiment.

Activity adapted from https://www.teachengineering.org/view_activity.php?url=collection/cub_/activities/cub_energy/cub_energy_lesson04_activity2.xml.

Consolidation/Extension

Students may learn about how materials scientists and nanotechnologists are developing ways to improve the efficiency of machines and lower CO_2 levels by improving lubricants for vehicles and heavy equipment.

Students watch video "Scientists on quest for friction-free oil" to learn more about how one oil company is working to decrease the CO_2 emissions of vehicles.
https://www.sciencedaily.com/videos/72b8312f94b135ce1766db9b2c0832d0.htm
Science Daily
Science Videos
Reuters - Innovations Video Online / Powered by NewsLook.com
November 23, 2015
Retrieved February 21, 2016

And students read "Increasing oil's performance with crumpled graphene balls"
https://www.sciencedaily.com/releases/2016/01/160125185043.htm

Exit Card
Friction Exit Card (See Link)