Electrostatics

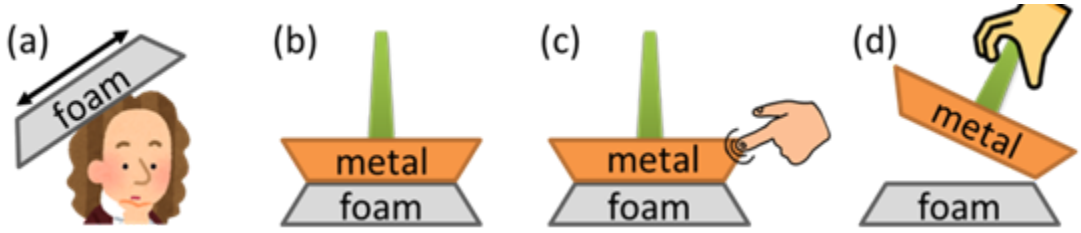
Objectives: By the end of this lesson, learners should be able to

- Describe the electrostatic charge generation through a rubbing or induction method
- Explain how the experiments show two signs of charges

Equipment: rubber balloon, foam plate, aluminum plate, electroscope, E-field detector

Activities:

- Rub a rubber balloon against human hair to confirm the charge generation on the balloon with the electroscope. Use the E-field detector to test the sign of the generated charges.
- Follow the steps below to generate charges on a metal plate with an induction method. Use the electroscope and the E-field detector to confirm the charge generation and to test the sign of the charges.



Thinking:

- How does the electroscope show the existence of charges?
- Why can the E-field detector tell the sign of charges?
- How does the induction method work to produce charges?

Resources:

Levitating Bulb

Objectives: By the end of this lesson, learners should be able to

- Describe the operation of a levitating bulb system
- Explain how magnetic levitation is realized
- Explain how wireless power transfer is realized

Equipment: a levitating bulb set

Activities:

- Place the bulb about half an inch above the base. Carefully move the bulb to find a spot where it stably floats.
- Touch the power icon on the base to light up the levitating bulb.

Thinking:

- What components should the base and the bulb have to realize magnetic levitation? How?
- What components should the base and the bulb have to realize wireless power transfer? How?

Resources:

https://en.wikipedia.org/wiki/Magnetic_levitation
https://en.wikipedia.org/wiki/Wireless_power_transfer

https://www.youtube.com/watch?v=anZqUhv1yHQ&t=20s

Sterling Engine

Objectives: By the end of this lesson, learners should be able to

- Describe the operation of a Sterling engine
- Explain the energy conversion in the Sterling engine

Equipment: Sterling engine set, ethyl alcohol, candle lighter

Activities:

- Light the alcohol burner. Let the light heat the cylinder for half a minute. Give the wheel a gentle push to start.
- Observe the structure, the motion, and the effect of the engine.

Thinking:

- How do the two engine cylinders work?
- What types of energies are involved in the operation? How do they convert?

Resources:
https://en.wikipedia.org/wiki/Stirling_engine

Scan the QR code to see a Sterling cycle animation :

Eddy Current Brake

Objectives: By the end of this lesson, learners should be able to

- Explain how eddy currents are produced
- Explain how the eddy current brake works to slow down a moving object

Equipment: copper pipe, PVC pipe, magnet

Activities:

- Hold the copper pipe vertically and drop the magnet through the pipe. Observe the falling speed of the magnet.
- Repeat the process with the PVC pipe and compare the results from the two trials.

Thinking:

- How do the two trials verify the existence of eddy currents? How and where are the currents produced?
- How do the eddy currents slow down the moving magnet? How do the energies convert?

Resources:

https://en.wikipedia.org/wiki/Eddy_current_brake

Galilean cannon / stacked balls

Objectives:
By the end of this lesson, students should be able to

- Use conservation of linear momentum and energy
- Describe what happens during an elastic collision

Equipment:

- 3 balls of different sizes (e.g., a basketball, a bouncy playground ball, and a tennis ball). A racquetball works well too.
- Smartphone slow-motion video

Activities:

- Drop one ball at a time and observe how high it bounces from the floor
- Stack the 3 balls on top of each other and drop. Observe how high they bounce up

Thinking:

- How does the small ball jump so much higher than where it was dropped? How do you reconcile this with conservation of momentum and energy
- What will happen if the three balls are of the same size?
- Can you think of practical applications of such systems?

Resources:

- https://en.wikipedia.org/wiki/Galilean_cannon

Tesla Coil

Objectives:
By the end of this lesson, learners should be able to

- Describe the operation of a Tesla coil
- Explain the observed electrical phenomena
- Explain the main function of a Tesla coil

Equipment: Tesla coil set, fluorescent light bulb

Activities:

- Turn on the Tesla coil. Watch, hear, and smell the discharging process.
- Hold the fluorescent light bulb in your hand and move it close to the Tesla coil. Observe any changes in the bulb.

Thinking:

- How do charges make light, sound, and smell in the experiment?
- Does the Tesla coil raise or lower the voltage? How to realize it?

Resources:

Rolling uphill and the center of mass

Objectives:
By the end of this lesson, students will be able to:

- Describe how an object can appear to roll "uphill" while its center of mass is moving downhill
- Describe that the motion of the center of mass should

Equipment:

- A V-shaped ramp with two rails and a spindle-shaped roller
- Optional: homemade with plastic funnels and wood (or use 3D printing)

Activities:

- Roll a cylinder-shaped object (e.g., a soda can) on the rail to identify the downhill direction
- Place the spindle-shaped object at the bottom, and observe it rolling uphill
- Observe it from the side: the center of the spindle is moving downward

Thinking:

- Why does the spindle appear to roll uphill?
- Can an object move uphill without an engine?

Resources:

Make your own demo:
https://skullsinthestars.com/2012/05/25/physics-demonstrations-rolling-uphill/

Friction and tug-of-war

Objectives:
By the end of this lesson, students will be able to:

- Explain how friction affects motion
- Explain that different surface textures lead to different friction

Equipment:

- 2 battery-operated toy cars
- A thread to connect the cars

Activities:

- Put the two cars on the table and let them pull away from each other. It should be a tie.
- Remove the rear tires of one car. Observe which car wins the tug-of-war.

Thinking:

- What is friction, and why does it matter?
- How did adding weight affect the results?
- Why is an icy road dangerous? How do we improve the friction?
- Why do tires and shoes have textures?

Resources:

Polarizers

Objectives:
By the end of the lesson, students will be able to:

- Explain polarized and unpolarized light
- Describing the phenomena of light passing through polarizers
- Use polarizers to identify the polarization of light in our surroundings

Equipment:

- Polarizing films, cut to appropriate sizes
- Holder of the films (e.g., stencils), with films glued to it

Activities:

- Search for polarized light (light reflected from cars, sky light, computer screens, etc.)
- Shine a flashlight through one piece of polarizer and project it on the table. It will appear fainter.
- Add a second polarizer. Rotate the second polarizer and see how the light becomes dimmer and eventually disappears
- Insert a third polarizer between the first two, at a 45-degree angle, and the light becomes less dark.

Thinking:

- When we use two polarizers, why does the relative angle matter?
- Why does the 3rd polarizer make the light less dark?
- Why are so many light sources polarized?

Resources:

Diffraction grating

Objectives:
By the end of this lesson, students will be able to:

- Explain how a diffraction grating works
- Interpret the diffraction gratings for different light sources

Equipment:

- Diffraction grating glasses (500 lines/millimeter)
- Laser pointers (red, green, and purple)
- Flashlight
- Color-changing LED lightbulb, lightbulb socket

Activities:

- Shine a laser pointer through a diffraction grating and project it on a screen/wall. You will see that the sources appear several times (interference). Repeat for another laser pointer of a different color.

- Shine the flashlight through a diffraction grating and project it on a screen/wall. You will see rainbows.

- Shine the flashlight and laser pointer together. Do the red laser pointer spots appear at the red part of the rainbows?

- Look at the color-changing lightbulb through the diffraction grating glass. Change the colors using the remote, and observe the composition of different colors

Thinking:

- Why do you see a rainbow?
- Why do you sometimes see a few colors instead of a rainbow?

Resources: