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

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:

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 it is still pulled down by gravity.
- Distinguish between an object’s center of mass and its geometric center.

Equipment:
- A V-shaped ramp with two rails and a spindle-shaped roller
- Gravity bird

Activities:
- 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.
- Place the tip of the gravity bird’s beak on the display stand. Observe its equilibrium state. Find its geometric center (roughly).
- Place the tip on your finger. Slightly shake the bird and feel its weight on your finger.

Thinking:
- Why does the spindle appear to roll uphill?
- What is the role of the center of mass regarding the static equilibrium of an object?

Resources:

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

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?

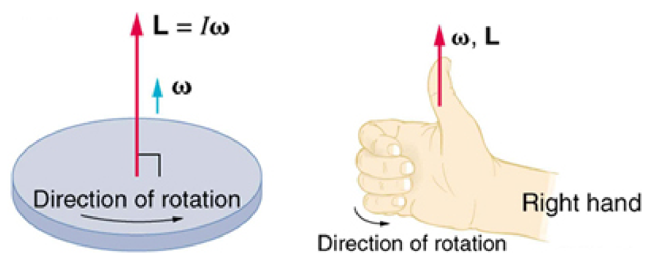
Resources:

Gyroscope

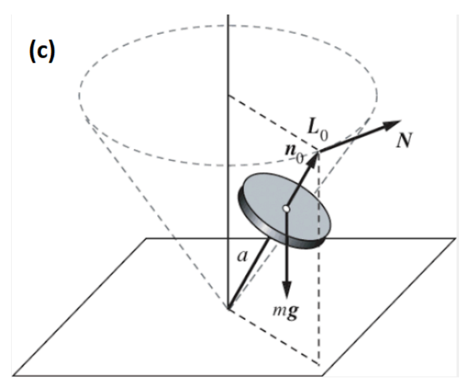
Objectives:
By the end of this lesson, students will be able to:
- Identify the angular momentum of a gyroscope
- Identify the external torque on a gyroscope
- Explain the precession of a gyroscope

Equipment:
- Gyroscope

Activities:
- Start the gyroscope:
  a. Pass the thread through the 2 mm hole on the flywheel (near the spindle).
  b. Rotate the spindle to wind the thread on the axis.
  c. Pull the thread quickly. The gyroscope should spin.
  d. Place the gyroscope on the base.
- Describe how the rotation axis of the gyroscope changes with time. Such motion of the rotation axis is called precession.
- Use a right-hand rule to find the angular momentum vector *L* of the gyroscope (following Figs. (a), (b)) .
- Use a right-hand rule to find the direction of torque produced by gravity: fingers go from the weight (*mg* in Fig. (c)) to the position vector towards the pivot (vector *a*), and then the thumb indicates the torque direction.
- A torque describes how the angular momentum changes with time. In this case, in what direction does the angular momentum change? Does it agree with the observed precession of the gyroscope?



(a) (b)



Thinking:
- If the spin of the gyroscope is reversed, how does the precession change?
- Why does the gyroscope not fall down immediately? Why does it eventually fall down?

Resources:

Magnetic field

Objectives:
By the end of this lesson, students will be able to:
- Describe the magnetic-field pattern of permanent magnets
- Visualize magnetic fields with magnetic materials

Equipment:
- Permanent magnets
- Magnetic viewing films
- Ferrofluid
- Magnetic field demonstrator

Activities:
- Place a permanent magnet behind the magnetic viewing film. Observe the pattern formation. Identify regions with strong fields and those with weak fields.
- Place multiple magnets behind the film. Change their positions and orientations. Describe the magnetic field pattern for each arrangement.
- Move magnets close to a ferrofluid. Describe the deformation of the ferrofluid.
- Shake the magnetic field demonstrator until the iron particles distribute uniformly in the fluid.
- Please a bar magnet

Thinking:
- From your observation, how do you explain the existence of magnetic field sources, called magnetic poles, on permanent magnets?
- How does your observation indicate that they are two types of magnetic poles? What is the difference between the magnetic fields produced by the different types of poles?

Resources:

Mirrors & Lenses

Objectives:
By the end of this lesson, students will be able to:
- Explain how mirrors reflect light and how lenses refract light
- Explain the focal points of curved mirrors and lenses

Equipment:
- 3-beam laser
- Concave/convex mirrors and lenses
- Ray-tracing worksheet
- Rulers and pens

Activities:
- Turn on the 3-beam laser and place it on the worksheet.
- Adjust the laser beams to be parallel to the axis.
- Place various mirrors and lenses at the origin and observe reflections or refractions of the beams.
- Use pens and rulers to trace (or extrapolate) the laser beams and find the focal points.

Thinking:
- Do any paraxial rays go or extrapolate through the same focal point?
- How does the curvature of mirror or lens surfaces affect their focal points?

Resources: