Energy Transformation	Grade 12 College Physics

Lesson Plan

Description

In this activity, students will consider different types of energy and their ability to change from one type to another. One of the results will be the creation of an interactive energy transformation simulator that can be used for educational purposes. You will be using the program Scratch.

Learning Outcomes

- Students will interactively investigate the transformation of thermal, mechanical, chemical, and light energy into other types.
- Students will learn advanced programming using Scratch.
- In the process of work, the basic energy formulas of various types will be studied/repeated.

Specific Expectations

E2.1 use appropriate terminology related to energy and energy transformations, including, but not limited to *work, gravitational potential energy, kinetic energy, chemical energy, energy transformations,* and *efficiency*

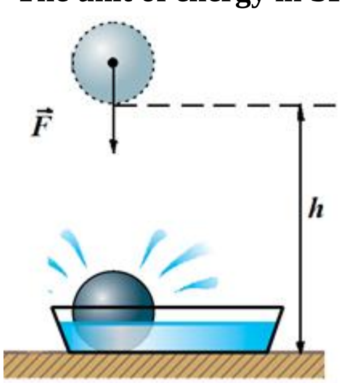
E2.5 investigate a simple energy transformation (e.g., the use of an elastic band to propel a miniature car), explain the power and output, and calculate the energy

Introduction

Energy is a physical quantity that characterizes the ability of a body (a system of bodies) to do work.

Energy is denoted by the symbol ***E***.
The unit of energy in SI is the joule:

$$[E] = \text{J}.$$



1. The potential energy of a body raised above the surface of the Earth

A body raised above the surface of the Earth has a certain energy due to the attraction of the body to the Earth. Such energy is called ***potential.***

The potential energy E_p is the energy caused by the interaction of bodies or parts of a body.

The potential energy of a body raised to some height **h** above the earth's surface is equal to the work that gravity **F** will do during the fall of the body from this height:

$$E_p = A = Fl$$

Because $F = mg$

$$l = h$$

$$E_p = mgh$$

m – body weight; *g* – acceleration of gravity; *h* – the height to which the body was raised.

2. Potential energy of an elastically deformed body

The potential energy **of an elastically deformed (stretched or compressed) spring** is determined by the formula:

$$E_p = \frac{kx^2}{2}$$

where *k* is rigidity; *x* — spring elongation.

The potential energy of springs is used in watches, various clockwork toys, cars, shock absorber spring cars and buffers.

3. Kinetic energy

Kinetic energy is the energy that a body has because of its movement (from the Greek. "kinema" — movement). A moving car, a flying plane, a rolling ball – all these bodies have kinetic energy.

Kinetic energy is the energy that is caused by the movement of a body and is equal to half the product of body mass by the square of its velocity.

$$E_k = \frac{mv^2}{2}$$

m — body weight; *v is the* speed of movement of the body.

4. Total mechanical energy

Quite often, the body has both potential and kinetic energies. For example, an airplane flying above the ground at a certain altitude has both potential energy (because it interacts with the ground) and kinetic energy (because it moves).

The sum of the kinetic and potential energies of the body is called the total mechanical energy of the body.

$$E_{total} = E_k + E_p$$

5. The law of conservation of mechanical energy

Based on numerous studies of the motion and interaction of bodies, like the examples considered, the law of conservation of mechanical energy was established.

Law of conservation of mechanical energy:

Energy does not disappear anywhere and arise from nowhere; it only turns from one type to another and is transmitted from one body to another.

Or this law can be formulated as follows.

Law of conservation of mechanical energy:

In a system of bodies that interact with each other only by elastic forces and gravitational forces, the total mechanical energy does not change:

$$\boldsymbol{E_{k0} + E_{p0} = E_k + E_p}$$

$\boldsymbol{E_{k0} + E_{p0}}$ — total mechanical energy of the system of bodies at the beginning of observation.

$\boldsymbol{E_k + E_p}$ is the total mechanical energy of the system of bodies at the end of observation.

6. Joule–Lenz law

The amount of heat that is released in a conductor with current is directly proportional to the square of the current, the resistance of the conductor and the time of passage of current:

$$\boldsymbol{Q = I^2Rt}$$

Q – the amount of heat generated by a conductor with current; I – current strength in the conductor; R – conductor resistance; t – current transmission time.

Other formulas follow from the Joule–Lenz law:

$$\boldsymbol{Q = UIt}; \qquad \boldsymbol{Q = \frac{U^2}{R}t}$$

It can only be used *when all electrical energy is spent on heating.*

If there are energy consumers in the circle section in which mechanical work is performed or chemical reactions occur, these formulas ***cannot be used.***

7. Heavy nuclear fission and nuclear chain reaction

• How do you know how much energy is released during any nuclear reaction?

The energy output of a nuclear reaction is the energy that is released or absorbed during a reaction.

$$E_{ex} = \Delta mc^2$$

E_{ex} – energy of nuclear reaction
Δm – defect in the mass of a nuclear reaction
c – speed of light propagation in a vacuum.

If $\Delta m = 1$ a. $m. u.$, then therefore: $E_{ex} = 931{,}5$ MeB

$$E_{ex} = \Delta mk \qquad k = 931{,}5\,\frac{\text{MeV}}{\text{a}.\,m.\,u}$$

A nuclear reaction mass defect is the difference between the sum of the particle masses before the reaction and the sum of the particle masses after the reaction.$(m_1)(m_2)$

$$\Delta m = m_1 - m_2$$

- If $\Delta m > 0$, then the reaction proceeds with the release of energy – *an exothermic reaction*.
- If $\Delta m < 0$, then the reaction proceeds with the absorption of energy – *endothermic reaction*.
- The energy yield of a nuclear reaction can be calculated in terms of the binding energy of nuclei:

$$E_{ex} = E_1 - E_2$$

E_1 – total binding energy of nuclei that react
E_2 – total binding energy of nuclei-reaction products.

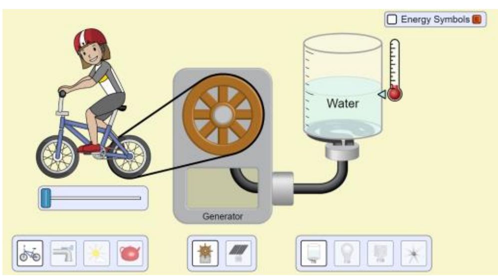
Action

Part 1

Tell the students some of the information above about energy.

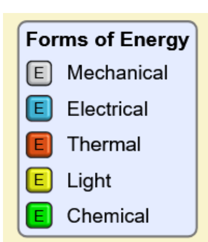
Introduction to «Energy Forms and Changes**»**

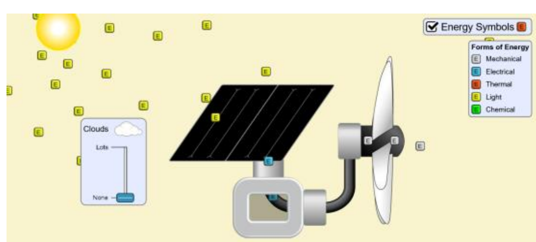
1. Ask students to go to the website and open the 'Systems' simulation: https://phet.colorado.edu/sims/html/energy-forms-and-changes/latest/energy-forms-and-changes_all.html



2. Ask students to create and write down some the possible energy conversions in this simulator and create the table of changes:

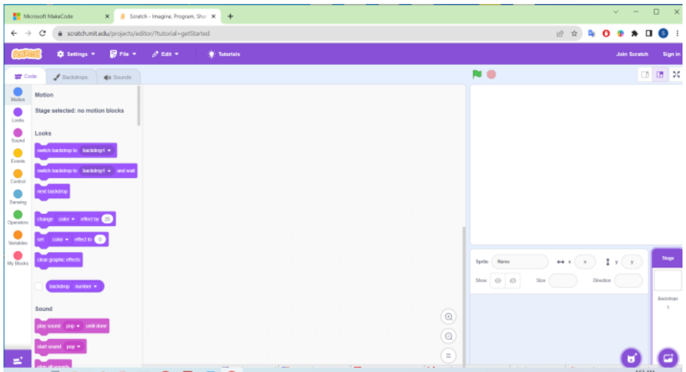
   Example: Light→ Electrical→Mechanical





Part 2 “Energy Transformations SIMULATOR”

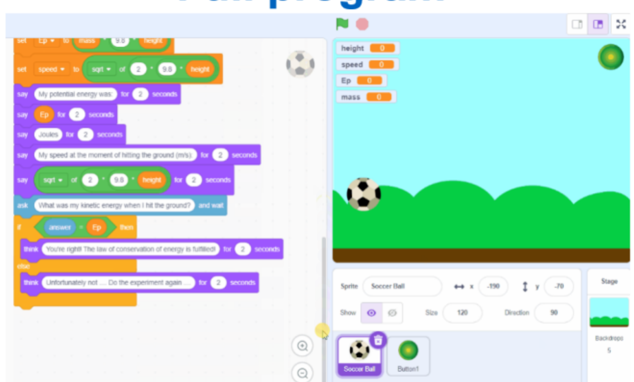
1. Ask students to open a new "Scratch" project: https://scratch.mit.edu/



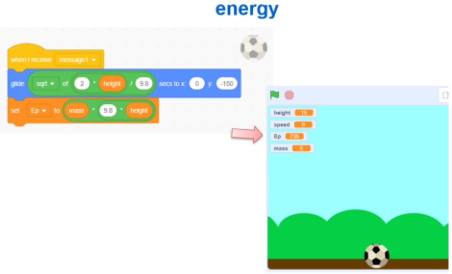
2. **<u>Use the presentation</u>** to further complete the task.

The emulator will demonstrate the transformation of the ball's potential energy into kinetic energy. Students will create their own program using the basic laws of physics.

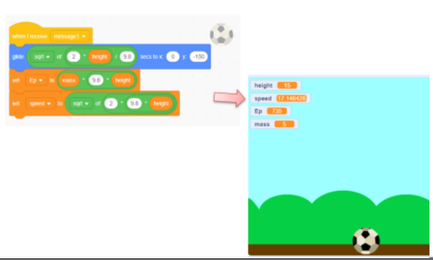
Full program



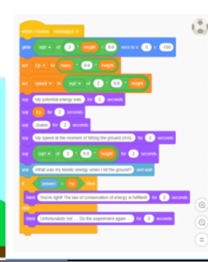
Extension 1. We add a display of potential energy



Extension 2. We add a display of speed



Extension 3.



We add interactivity and demonstrate the time the ball falls

Consolidation/Extension

1. Investigate which parameters are affected by the mass of a falling object.
2. Ask the students to identify which physical effects this emulator does not consider (friction for example).
3. Give an additional task to propose the idea of another simulator that will demonstrate other physical laws

Accommodations/Modifications

- You may only use the program and the first add-on to it only.
- Suggest students change the structure of the program.
- Use other objects instead of the ball.

Assessment

Not applicable. Or you can evaluate each item of the task with conditional points.

Additional Resources

Energy Skate Park: https://phet.colorado.edu/en/simulations/energy-skate-park
Pendulum energy**:** https://phet.colorado.edu/sims/html/masses-and-springs/latest/masses-and-springs_all.html