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Guiding Question: What forms of energy make up mechanical energy (the energy of motion)?

Students will have an opportunity to:

- Explain the way potential, kinetic and total energy relate to each other as an object moves up and down the track.
- Explore a variety of systems and observe the way the **total energy** of a system does not increase or decrease unless changes are made to the system (Law of Conservation of Energy).
- Develop an understanding of how friction affects energy changes of motion.

Background:

Students need a solid understanding of what "moving" means. I use a discussion revolving around a definition of changing ones position (mobile in the wind, skater spinning, etc.), shape (melting of a candy bar, squeezing a balloon) or location (rolling a ball, driving a car, etc.). I have included a simple lab I do as an anchor activity demonstrating "change in location" and introducing the rate of change of motion – speed. See Run, Walk, Jog activity

I introduce students to the types of energy we will be studying and use the following link: SCREAM - 6 Basic Types of Energy

Teacher notes:

indicates students write a response	indicates students discuss with partner
△ Indicates students should check in with teacher before going further	

- There are many things to do in this simulation so I have built-in guided exploration in the first few questions of the activity. I've included teacher check-points to check students' progress with content and to manage time. I make announcements periodically that students need to be checked off by a certain time.

- I want students to be able to discuss friction at the completion of the sim:
  - Friction (opposes) the motion of two objects in contact
  - With friction present, the total mechanical energy (potential and kinetic) decreases since some of the energy is transferred to thermal energy, yet the total energy always stays fixed.
  - Changing a "skater" changes the whole system and the total energy might be different, but the energy relationships will follow the same pattern.

- The activity can be done in one extended period or over two regular periods. The first two pages are designed to be one lesson covering conservation of energy, kinetic energy and potential energy. Page 3 is the follow-up adding friction to the skate park system. It could also be used in one period and finished as homework if students are comfortable with the sims and they have internet access outside of school.

- Follow-up discussion:
  - This is a great time to discuss which scenario (with friction or without) is more similar to our experience with skateboarding, swinging on a swing set or even coasting down a hill on our bike and then having to pedal up the next hill…

  - I also mention that the movement of objects is described by laws first explained by Isaac Newton. We cover them later, but I make the point that a great deal of mathematical and scientific work has gone into understanding how objects start to move, continue to move once in motion and what might stop their motion.

  - **How can we change the total energy of the skater?** – students have to tell me what this looks like (make the total energy bar taller) and we talk about exploring the question with a controlled experiment. In the end, we will have how we can go about explaining our answer by only changing one variable in the system.

    -Some answers my students introduce to the discussion are:
    - ☑ Change the track so there is less friction?
    - ☑ Make the track shorter so he flies off?
    - ☑ Make the skater stronger??? (Cannot test for this one – but it does often lead to the mass of the skater)
    - ☑ Choose a different object to put on the track – this does in fact change the total energy of the system –
      - How? Why? Make up an experiment that would show this idea and answer our question.

- Students will have a chance to build marble roller coasters after the simulation discussions are completed. I use pipe insulation foam bought at the hardware store – cut in half. I tell them their goal is a track with two hills, one loop and a curve. They get 3 pieces of the ½ sided foam, 10 cm of masking tape, 1 marble and a little cup to catch the marble at the end of the track. That is it! I remind them that they do not get additional supplies so they must have a "plan". I also point out that they must keep track of their marble because they cannot have an additional one.

- **Non-obvious controls: (adapted from "Tips for Teachers" byTrish Loeblein)**
  • Use the **Save** feature in the **File** menu to save a track and Skater position for lecture or homework.
  • You can resize the windows when you open the graphs and charts to make them fit.

-**Return Character** or **Bring Back the Skater** *(name changes with the character)* buttons do the same thing. The Skater is returned to the place where the user last placed it.

• You can **Pause** the sim and then put the Skater wherever you like easily. Then the **Return Character** (or **Bring Back the ..)** will let you rerun the scenario.

-The **Energy Position Graph** has a few subtle features. It erases as the sim Plays, but you can **Pause** the simulation and the graph will not change. The **Copy** button will let you freeze the graph to compare different scenarios, but it cannot be saved as a file. If you **Zoom**, the graph clears; you can make a new graph by rerunning your scenario using **Return Character**.

If you use the **Show Path** feature, you can click on the purple dots and show quantitative information. Height refers to height from Potential Energy Reference line. Click again to hide.

-Step is a good way to incrementally analyze. It is very useful to have the students make predictions. The button next to **Play** in the large window moves the character forward in time. The button in the **Energy Time** window moves the vertical curser on the graph (Steps through the Playback).

-If you are doing a lecture demonstration, you should set your screen resolution to 1024x768 so the simulation will fill the screen and be seen easily.

Important modeling notes / simplifications:

When the Skater lands on the track, the vertical component of his kinetic energy is converted to thermal energy. You can do experiments where there is no energy loss to thermal (only PE and KE conversions) by making sure he doesn't leave the track. (No jumps or use the roller coaster mode). Right click on the track brings up roller coaster mode.