Counting Joules

Time: about 20 minutes.
Topic: Conservation of Energy.
Type: Tangible

Overview:

This activity uses "energy dollars" to demonstrate in a tangible manner how energy is conserved as it is transferred from one type of energy to another.

Objective(s):

1. The students will recall that energy is conserved as it is moved from one form to another.
2. The students will calculate the amount of energy in one form by calculating the energy in other forms and the total energy at a different time.

Prerequisites:

The students should be familiar with the ideas of work, gravitational potential energy and kinetic energy. This activity is intended to be the first activity to pull these ideas together with conservation of energy.

Equipment and Materials:

- 20 Joule notes ("energy dollars") per group.
- A sheet of paper labeled "The rest of the universe" per group.
- A sheet of paper labeled "The System" divided in two sections, one labeled "Kinetic Energy" and the other "Gravitational potential energy" for each group.

Misconceptions:

Energy is an abstract concept that is difficult for many students to grasp, and this activity seeks to make it a more tangible idea by drawing an obvious allusion to money.

Other student difficulties:

Activity Table:

Task	Reason	Notes
Distribute the sheets and the Joule notes. Ask each group to count out twenty Joules.	Get set up.	It can take some groups longer to count out enough Joules than you might expect.
Explain that, as a class, you are going to describe a roller coaster, which is currently sitting at the bottom taking on passengers. The energy to make it go is sitting in the	Introduce a familiar scenario and give practical examples of what the terms "the system" and "outside the system" would mean.	You could help to visualize this by drawing a roller coaster at the bottom corner of a clean white board.

motor or in the power lines. The "system" in this case is the roller coaster, so have them put all 20 Joules on the "Rest of the Universe" sheet.		
State that now the motor is causing the cables to pull the cars to the top of the first hill. Observe that the cables are exerting a force causing it to move a distance, and ask them what the cables are doing.	This should be a reminder of the definition of work.	If you don't get immediate volunteers, prompt the students until they connect this to the definition of work. If you are drawing, draw the track going up the first hill.
Observe that now that the car is at the top of the hill, it has more energy. Ask the students what type of energy it has (potential). Explain that is a function of work: when an outside force does work on a system, it transfers energy in or out of the system. Tell the students to do some work and move their 20 Joules from "The rest of the Universe" to "Potential energy."	This should be a reminder of what gravitational potential energy is and an example of how work figures into the conservation of energy.	
Tell the students that now the cars roll down the hill, picking up speed. Ask them what kind of energy they have now (kinetic). Tell them to transfer 18 Joules (or so) to "Kinetic Energy."	This should be a reminder of what kinetic energy is, and it is beginning a series of transformations between different types of energy	During this next series of steps, many students will be mechanically following instructions without seeing the point. That is OK; the 'aha' moment comes latter. If drawing, draw the track going down the hill.
Mention that even a good roller coaster has friction on the tracks, so friction does work on the cars, taking energy away and converting it to thermal energy in the tracks. Thermal energy is energy in the rest of the universe that is no longer available for doing work on the system, so have them take 3 Joules from kinetic energy and put them *under* the "Rest	Another example of outside interactions doing work, this time taking away energy to somewhere else.	

of the Universe" sheet.		
Tell them the roller coaster has now gone up the next hill. Ask them "We have now converted what kind of energy into what kind of energy?" (Kinetic into potential.) After getting a response, have them transfer 12 Joules (or so) back to potential.	Another reminder about the relationship between kinetic and potential energy, as you transfer back and forth.	As you go through these steps, watch to make sure students have enough time to count out the number of Joules to transfer.
Go though 3-5 more iterations of going down a hill (students transfer Joules from PE to KE) losing energy to friction (students move Joules from KE to under the "Rest of the Universe" sheet) and going up the hill (students move Joules from KE to PE). Make the quantities different each time (e.g. down 5, lose 1, up 4, down 10, lose 3, up 5, down 2, lose 1, up 8, etc.). Arrange it so that at the end over half of the energy is under the sheet and the rest of it is KE.	This will give the students plenty of practice in transferring from one category to another, so that they are comfortable with it and see that there is nothing special about the first set of numbers. The varying numbers will make sure that it is not easy to remember all the steps and calculate the energy that way.	Ideally you want to do this long enough that the class is just starting to get board. It needs to be long enough that they won't have in memory all the additions and subtractions, but not so long that you loose most of the students. Getting the final Joule distribution to have the majority under the "Rest of the Universe" sheet and the rest KE is important to set up the next step.
Ask the students to tell you how many Joules are under the "Rest of the Universe" sheet ***without looking under it***.	This is the basic idea of most conservation of energy problems—figure out how much energy is in one category by the amount missing.	Students may look at you like you are asking a stupid question and may hesitate responding because is seems so simple.
When some students respond, ask them how they figured it out, *without looking under the sheet.*	Get students to explain how to do this.	You should get something like, "Well, I just counted up what was left and subtracted from 20."
Reiterate what the students said, emphasizing several times that they subtracted what they had left from what they started with.	Make sure every student understands the idea of subtracting the final from the starting.	
Explain that this is the big idea about conservation of energy; it doesn't matter how you got from one point to another. All you do is take all the energy	Bring out and reinforce the main idea that students are to learn from the activity.	It is only at this point that some students will realize the method in your madness. Emphasize that, yes, it really is that simple—it is just

you had at the beginning and subtract what you know at the end, or vice versa.		addition and subtraction, and no vectors to worry about.

Use notes: (Students don't seem to get as much of a kick out of the "energy dollars" as physics teachers.)

Necessary Files:

None.

Results:

Depending on your numbers, students should wind up with 5-10 Joules in the KE section and the rest under the "Rest of the Universe" sheet.

Related Activities:

Follow-up activities:

This would be a good lead-in to doing some simple conservation of energy calculations

References:

History:

This was initially used at WKU algebra course, Fall 2001. It went fairly well; many students followed the instructions mechanically, but at the end many faces showed that they had gotten the point.

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