Energy-Beans Procedure

Purpose: To track energy transfers and transformations in a system

System: A car with a gasoline-powered engine

Materials

For each pair of participants:

- 30 dried pinto beans
- 6 one-ounce plastic or paper cups

Possible Energy Forms

- Chemical energy
- Kinetic energy
- Gravitational potential energy
- Internal energy

Representations

- Energy = beans
- Forms of energy = cups
- Areas of energy flow = circles
- Energy transformations = movement of beans from cup to cup to signify energy changing forms
- Mountain = gravitational potential energy
- Speedometer = kinetic energy
- Fuel-tank meter = chemical energy
- Engine piston (red rear wheel) = internal energy (performs work on wheels to give the car kinetic energy)
- Brakes (red front wheel) = internal energy (converts to heat energy when brakes are applied, which reduces the car's kinetic energy)
- Pavement (red circle) = internal energy (converts to heat energy from wheels' rolling friction and braking)
- Atmosphere = heat energy (end destination of any heat that transfers away from red objects)

Cups

*Cups are placed on the circles in handout 7.4 (Energy-Beans Worksheet).

- Beans on mountain (blue circle)
- Beans on speedometer (blue circle)
- Beans on fuel-tank meter (blue circle)
- Beans on car's engine piston (red circle, rear wheel)
- Beans on car's brakes (red circle, front wheel)
- Beans on pavement (red circle)

Rules

1. Beans in a cup on a red circle (indicating elevated temperature) can migrate slowly into the atmosphere as heat energy but can't be put back in a cup (transform into another form of energy). This signifies that heat in the system ultimately rises into the atmosphere, where it remains.
2. Beans on the mountain can convert from potential energy to kinetic energy.
3. Beans in the fuel tank can convert to engine heat. Engine heat transforms into kinetic energy, which makes the car gain speed.
4. You must release 4 beans into the atmosphere (as heat) for every bean that goes into the speedometer cup.
5. As the car moves along the road, 1 bean goes into the pavement for every 4 beans in the kinetic-energy cup.
6. Applying brakes requires a transfer of beans (as kinetic energy) to the brakes.
7. Driving uphill requires transferring some beans to the mountain and storing them as potential energy for later use.

Directions

1. Each bean represents a packet of energy, and each cup represents a form of energy. Circles on the Energy Beans Worksheet (handout 7.4) represent forms of energy that correspond to various objects.
2. Beans are divided among the cups, and the cups are placed on different energy circles on the worksheet.
3. Energy transfer (from place to place or object to object) is possible through work and heat. Energy transfers out of the system when beans are moved out of a cup and placed in the atmosphere. Energy transformations take place in the system when beans are moved from cup to cup, signifying that energy has changed from one form to another.
4. At the beginning, all of the beans should be placed on the worksheet, either in the atmosphere or in one of the cups on the energy circles.
5. For each of the following scenarios, discuss with your partner how your 30 beans should be distributed in the specific scenes. Then move your beans from cup to cup to simulate the energy transfers and transformations that are taking place.
6. Describe the energy transfers and transformations in your science notebook, making sure to include the number of beans transferred from cup to cup.
7. Discuss the questions with your partner and write your answers and evidence in your notebook.

Scenario 1: Coasting Downhill

You're in your car at the top of a mountain with no gas in your tank. Fortunately, you see a gas station in a distant valley. Decide how your 30 beans should be distributed in each of the following steps:

1. The car is sitting perfectly still at the top of the mountain, and you're pondering what to do.

2. After a shove, the car starts moving down the mountain.
3. The car picks up speed halfway down the mountain.
4. The car reaches level ground at the bottom of the mountain and coasts.
5. The car is coasting too fast, so you slam on the brakes, and the car comes to a complete stop in front of the gas pumps.
6. You hang around the gas station for an hour with the engine off.

Questions

1. What form(s) of energy is represented in each step? What energy transfers and/or transformations take place?
2. How are your energy beans distributed at the end of the scenario?
3. What would it take to drive back up the mountain?

Scenario 2: Driving Back Up the Mountain

At the gas station, you purchase 30 energy beans to fuel up your car. Decide how to distribute your beans in each of the following steps:

1. You start your car and let it idle for 2 minutes while texting friends.
2. You push the gas pedal, and the car accelerates on level ground until it reaches a constant speed.
3. The car is moving at a constant speed on level ground for 3 minutes.
4. The car ascends the mountain for 10 minutes.
5. At the top of the mountain, you apply the brakes and come to a stop.
6. You shut off the engine.

Questions

1. What form(s) of energy is represented in each step? What energy transfers and/or transformations take place?
2. What does it take for the car to idle?
3. What does it take for the car to accelerate to a constant speed?
4. What does it take for the car to drive 1 minute on level ground?
5. What does it take for the car to drive up the mountain for 1 minute?
6. How are the beans distributed at the top of the mountain?