TEACHERS GUIDE

DRINKING BIRD
ITEM # 7010-10

ENERGY - HEAT

Drinking Birds work using properties of thermodynamics, converting thermal energy into mechanical energy. Fluid inside condenses from the evaporative cooling of the water off the birds beak, making it top heavy and dunking it back into the water. The condensate rejoins the liquid pool in the bird's bulb, and he tips up again. The process continues indefinitely.

Materials

- drinking birds
- 0.001g pan balances
- stop watches
- bell jar (or other enclosed clear container than can hold the drinking bird while cycling)
- fan
- beakers
- water
- isopropyl alcohol
- light bulb with lamp clip

Goals & Objectives

see page 7 for National Next Generation Science Standards

Introduction

The drinking bird undergoes a cycle which at first may appear to be perpetual motion. The first law of thermodynamics states that energy cannot be created or destroyed merely transformed. The second law describes how some energy escapes any system any time energy is converted and therefore perpetual motion machines are impossible.

The drinking bird is not perpetual motion because thermal energy must always be removed (via heat transfer) from the head in order to create the vapor pressure differential with respect to the bottom of the bird. If the liquid has a center of gravity that allows it to pivot on a fulcrum, you have an example of a heat engine. Thermal energy differences transforming into mechanical energy.

The toy drinking bird will let you cleverly intrigue your students to discuss the laws of thermodynamics, perpetual motion, changes in state, energy transformations, energy transfers, forces, and motion.

National Next Generation Science Standards

Students who demonstrate understanding can:

4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.

4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer

MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

Standards Key

K = Kindergarten
3 = 3rd Grade
(numbered by grade)
MS = Middle School
HS = High School
PS = Physical Science
LS = Life Science
ES = Earth Science

HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

Discussion

Additional Discussion and Real Life Applications

1. How are earth's systems heat engines? (hydrosphere and atmosphere)
2. How do power plants use heat engines to operate?

Assessment

1. Participation, discusssion and vocabulary.

2. **Vocabulary:**
thermal energy
condensation
vapor pressure
heat engine
heat cycle

How it works

A drinking bird is an example of a heat engine. It converts a difference in temperature (between the head cooled by evaporation and the bottom at room temperature) into cyclical motion.

When manufactured, most of the air is removed from the inside. The gas that remains is mostly vapor from the liquid, which vaporizes at low temperatures (much lower than water).

When the fuzzy coating on the bird's head is wet, water evaporates and cools the vapor inside the bird's head. This condenses the vapor back to the liquid state and reduces the pressure in the bird's head. (Pressure is caused by vapor particles hitting the side of the container – less vapor fewer collisions with the sides of the container. In addition, liquid particles take up less space)

Since the vapor pressure in the bird's body is now higher than the vapor pressure in its head, liquid is pushed up the tube toward the head. The center of gravity of the bird is raised, and the bird begins to tip around its fulcrum. When the bird finally dips into the water, a clear passage is opened between the head and the body, allowing a bubble of vapor to travel to the head and equalizes pressures and the liquid to fall back down to the body.

The bird returns to the upright position because it is now bottom heavy (gravity pulls more on the bottom half) and the whole process repeats.

Each time the bird's beak dips into the water, it absorbs a little water to replace any that has evaporated. This prevents the bird's head from drying out. The bird will continue its cycle until the head dries out, and evaporation can no longer cool it.

ACTIVITIES

1 Demonstrate how the drinking bird operates.

a For younger students discuss the conversion of thermal energy into mechanical energy.

b For chemistry students, a discussion of gas laws and states of matter.

c For physics students, a discussion of thermodynamic cycles – the drinking bird is an example of the Rankine cycle. What would happen if the room had 100% humidity? (You can use a bell jar placed over the bird to demonstrate this.)
- Evaporation stops quickly and does not resume until you remove the bell jar.

2 Hold the bottom of the drinking bird and allow students to make an observation of what happens at the head.
- It boils because of the low boiling point of the liquid) Boiling does not mean hot (a common student misconception) it is when a liquid begins to change into a vapor, both states exist simultaneously.

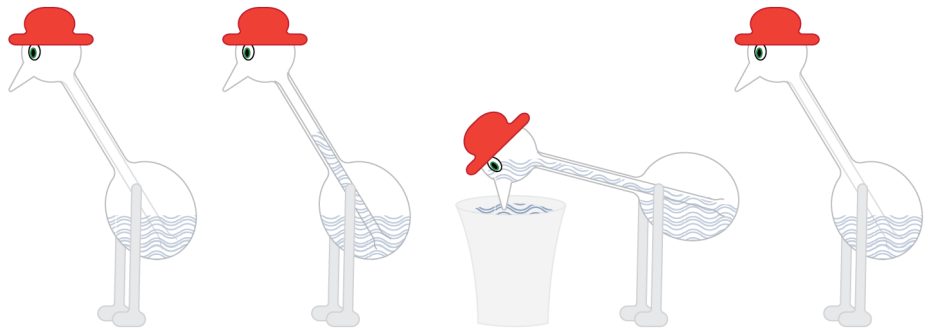
3 Measure the evaporation rate by placing the bird on a sensitive (0.001g) electronic balance as it cycles. Measure how long it takes to complete one cycle. Graph the evaporation rate versus time to complete cycle.

4 Ask physics students to diagram the forces acting on the bird (and/or fluid) at various points in time.

5 **a** Predict what would happen if you painted the neck and lower bulb black and exposed the head to a hot light bulb?

***Note**
It is always best to practice an experiment ahead of time to be able to best present it to the class.

ACTIVITIES



b Predict how dipping the bird head in alcohol would affect the cycle. (if you experiment with this make sure the student has only as much as they need and there are no sources of ignition nearby)

c Predict how a fan pointed at the head would affect the cycle. If you have enough drinking birds divide students up into groups and have them measure the normal cycle of their bird and compare it to the variable they have chosen.

6 Have group present the results to the class and discuss.

If you have access to tiny thermocouplers (ask your physics teacher – this is appropriate for young children as well).
Attach one to the top and one to the bottom bulb and relate this to time dependence for a cycle to complete.

Ask students how they could graph the data to visually show the relationship between the two variables.