Name _____ Date _____

Activity 3: Dippy Duck

Introduction:

Dippy Duck is a toy, or in terms of physics, a heat engine that uses thermal energy from the air to make the bird heads bob up and down as if it were in a state of perpetual motion. Of course, there is no such thing as perpetual motion so what is going on here. The drinking bird consists of two glass bulbs joined by a glass tube (the bird's neck). The tube extends nearly all the way into the bottom bulb and attaches to the top bulb but does not extend into it. The space inside the bird contains a fluid, usually colored. The fluid is typically dichloro-methane, also known as methylene chloride (CH_2Cl_2). It is bluish in Fig.1 The gas inside the bird above the fluid is Methylene Chloride vapor! The Methylene Chloride is a volatile liquid. This means that it has a boiling point very close to room temperature. As a result, the Methylene Chloride inside the bird is in, what we call, thermal equilibrium resulting in a coexistence of its gas phase and its liquid phase.

Fig. 1 Dippy Duck poised to dunk into a cup of water

Next, you need to know that the bird's head is a glass bulb (like the bottom) but the head is covered with a felt-like fabric that absorbs water. So, to start the drinking process the bird's head must be covered in water. Once this happens, the water on the head begins to evaporate and cools the head a little bit. This decrease in temperature causes some of the Methylene Chloride vapor in the head to condense into a liquid and fill up the neck a little bit. Since the liquid phase takes up much less space than the vapor phase, there is fewer vapors in the head to fill up practically the same volume. This means that the pressure in the head will *decrease,* causing a

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Name _____ Date _____

difference in pressure between the head and the base of the bird. A difference in pressure results in a net force from the higher-pressure area to the lower pressure area. This means that the little bit of vapor in the base of the bird forces the liquid up the neck and into the head. This gives the bird a heavy head and forces it to dip. Once it dips, the liquid moves out of the way, letting the warmer vapor in the bottom move up the tube to the top warming the head a bit and starting the cycle all over again.

Objective: To understand the physics behind how dippy duck works.

Materials:

- Dippy Duck
- Glass of water

Virginia SOLs: PS.1b, PS.1d, PS.1k, PS.1m, PS.2f, PS.5c, PS.6b, PS.6c, PS.7a, 3.1h, 3.1j, 6.1c, 6.1h, 6.2e

Suitable for students in grades 6-12

Prediction:

Before you dip the head in water and release it, predict the behavior of dippy duck over the next few minutes.

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Procedure:

1. Fill a glass cup with water to almost the top as shown in Fig.1 and arrange dippy duck so that its beak can strike the water when bent over. Now push the head in the water with your fingers and release it. Describe the behavior of the head of dippy duck and the fluid in the tube over a period of a few minutes.

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2. You will be asked several questions to help you understand what is going on**.** You may discuss these questions with your partner and/or Google for answers. Hold the bottom bulb in the palm of your hand as shown in Fig. 2. Before you hold it, predict the behavior here.

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Name _____ Date _____

3. Was your prediction correct? Describe your observations here.

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Fig. 2 Instructor using fingers to warm the fluid inside the bulb

4. Using concepts of temperature and pressure of gases and fluids explain your observations here.

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5. Slide the metal band shown in **Fig. 3** up and down and see what effect it has on the action of dippy duck. Describe what role the metal band plays in the motion of dippy duck.

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Name _____ Date _____

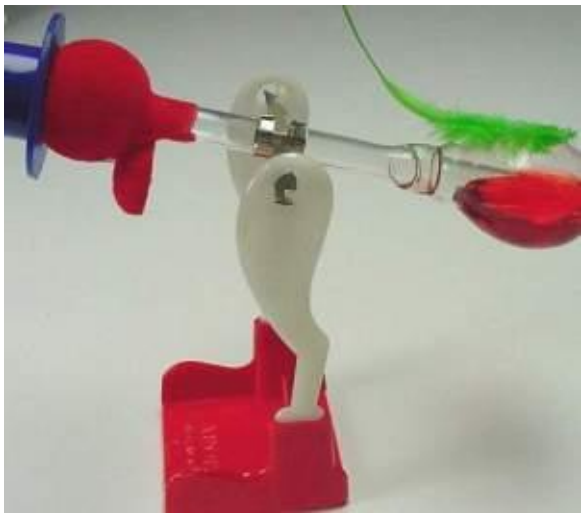

Fig. 3 Close up emphasizing the metal band near the cm of Dippy Duck's head, bulb with fluid, and glass tube.

6. Measure the temperature of the hot water coming out of the tap and determine if it makes any difference if you use hot water in the glass cup. Predict the behavior here.

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7. Describe your observations here. Was your prediction correct?

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8. Explain your observations here.

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9. Replace the water in the cup with alcohol. Your Lab instructor will prepare this for you and you will share the alcohol with others. Predict how using alcohol instead of water will affect the motion of dippy duck.

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10. Describe your observations here. Was your prediction correct?

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Name _____ Date _____

11. Explain your observations here.

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