Name: _____ Date: _____

Gizmo Activity: Reflection (Part 3)

Open tubes… A closer look
A high-pressure region that starts at the left end of a flute will still be a high pressure region when it nears the right end. However, after it turns around, it will have experienced a phase change of 180 degrees, becoming a low-pressure region instead. It moves back toward the left, staying a low-pressure region until it reaches the end. When it reflects off the open end, it will again be a high-pressure region moving to the right.

Thus, a pressure wave must travel all the way down the tube and back again to complete one cycle. If a driving force pushes it from one end every time the wave reaches the edge, the situation will be quite similar to a person being pushed on the swing once a cycle. To find the natural frequency of the tube, one simply has to determine how long it takes for a sound wave to go back and forth one time.

> For an open tube, the natural period equals the time required for sound to travel twice the length of the cylinder.

1. How far must a pulse travel during a cycle in an open tube 67-cm long? _____

2. The speed of sound inside a musical instrument is about 350 meters per second. At that speed, how long does it take a pulse of high-pressure air to travel the length you gave above? Show your work below.

3. What frequency does this period correspond to? _____

   (Note: This frequency is very near middle C.)

4. Imagine a hole is drilled in the tube, allowing air to escape before reaching the end. Instead of a length of 67 centimeters, the effective length is 39.75 cm. What is the natural frequency of the flute now? Show your work below.

5. How does this last question relate to flutes? _____

   _____

Closed tubes

Everything is different at the end of a closed tube. There is no outside air pressure to balance things out, so the pressure can be very high or very low (or anywhere in between) at the end of the cylinder. Furthermore, there is no outside air to get sucked in. Instead, the high-pressure pulse just bounces off the closed end with no phase change. Similarly, when a low-pressure pulse hits the end, a low-pressure pulse bounces back.

Because reflection is different off an open end than off a closed one, the acoustics of a semi-open tube, like a clarinet, have a couple interesting twists. For the questions below, assume the left end of a 67-cm clarinet is open and the right end is closed.

1. A high pressure region begins at the left end of the clarinet and moves to the right end.

    A. After it has gone a little less than 67 cm, it is near the right end but has not reached it. Fill in the blanks below describing the wave at this point.

    The pressure is _____ (high or low) and moving toward the _____ (left or right).

    B. Describe the wave after it has reflected from the right end.

    The pressure is _____ (high or low) and moving toward the _____ (left or right).

    C. Describe the wave after it has moved nearly 67 centimeters back toward the left end, but has not reached the end.

    The pressure is _____ (high or low) and moving toward the _____ (left or right).

    D. Describe the wave after it has reflected off the open left end of the cylinder.

    The pressure is _____ (high or low) and moving toward the _____ (left or right).

2. The pulse had the following starting conditions:

    - It started its cycle as a high-pressure pulse (not a low-pressure pulse).
    - It started its cycle at the left end of the tube.
    - It started its cycle as a pulse moving to the right.

    When the pulse gets back to the left edge and turns around, it does not match all these conditions. After it reflects (so that it is moving back to the right), it is a low-pressure pulse rather than a high-pressure pulse. In the space below, continue the above thought experiment until the pulse meets all three conditions. How far in total does it have to go?