People Demos: Kinesthetic Physics Activities

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The demonstrations presented in this talk are called "people demos" because the principal, if not only, equipment necessary to perform them is people. These student-centered, kinesthetic activities provide an essentially no-cost way of illustrating wave motion, electrical circuits, interference, as well as other physical phenomena.

In addition to their low cost, we feel that kinesthetic activities are valuable for a number of reasons. They get the students involved with the phenomena in an enjoyable way. In addition, interpreting phenomena through physical activity helps students grasp abstract concepts. And finally, we feel that principles that are "performe" are less likely to be forgotten.

Transverse People Waves

Many features of transverse and longitudinal waves may be demonstrated through the use of people demos. To simulate a transverse wave, students stand in line one arm-length apart. The teacher then starts counting. On the count of one, student #1 takes one step forward. On the count of 2, student #1 takes another step forward while student #2 takes his first step forward.

On the count of three:

(a) student #1 takes one step backward

(b) student #2 takes second step forward

(c) student #3 takes first step forward

On the count of four:

(a) student #1 takes his second step backward

Student #1 has now returned to his initial position and will remain stationary

for the remainder of the demonstration.

(b) student #2 takes first step backward

(c) student #3 takes second step forward

(d) student #4 takes first step forward

Eventually, each student will take a four-step trip: two steps forward and two steps backward. A student will not take his first step forward until the person on his left takes his second step forward. What will be observed is a single pulse with an amplitude of two steps traveling along a medium of people (Fig. 1). The speed of propagation is independent of amplitude. Hence, each student could have taken a six-step trip, three forward and three backward, and the speed of the leading edge of the pulse would be the same.

Note that the particles that make up the medium (people) are moving perpendicular to the direction of the wave. Students move forward and backward while the direction of propagation for the wave is left to right.

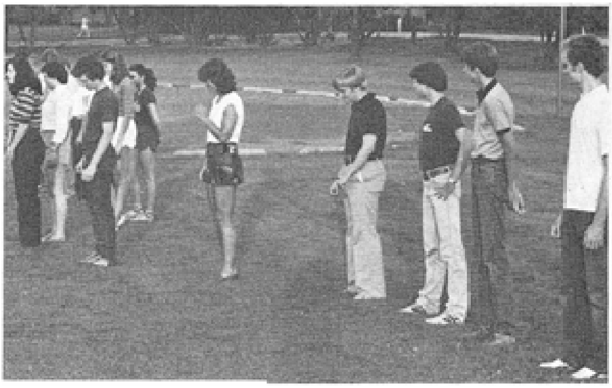

Figure 1. A transverse wave of people.

Longitudinal People Waves

A line of people, double arm-lengths apart, can be used to demonstrate a longitudinal wave. The instructions for this people demo are similar to the transverse wave except each student will now take two steps to his right followed by two steps to his left.

On the count of one, student #1 takes one step to the right. On the count of two, student #1 takes his second step right while student #2 takes his first step to the right.

On the count of three:

(a) student #1 takes one step to the left

(b) student #2 takes second step to the right

(c) student #3 takes first step to the right

On the count of four:

student #1returns to his starting position

student #2 takes his first step to the left

student #3 takes second step to the right

student #4 takes first step to the right

Eventually, each student will take a four-step trip: two steps to the right, and two steps to the left. Regions of compression and rarefaction will be observed moving along the line of people. Again, the speed of the wave is independent of amplitude.

Sound and Light Demonstrations

In an attempt to illustrate acoustical phenomena on a large scale, we have an annual "sound and light" show in the school's auditorium. The program consists of demonstrations of interference, diffraction, and reflection of sound waves. We begin by reviewing the principle of superposition of waves. This is accomplished by showing a short video on superposition. Two-dimensional interference, a topic previously presented in class, is then illustrated by projecting a ripple-tank interference pattern on a screen.

A transition from water waves to sound waves is made by using two loudspeakers to approximate point sources. While these two sources (typically 3-m apart) are being driven in phase at a fixed frequency (for example, 500 Hz), students are asked to move to points in the auditorium where the sound level is low. By using a large number of students, an easily discernible nodal pattern emerges. While the students remain in their seats, where the sound level was determined to be low, first the frequency and then the separation of the sources are changed. The resulting changes in the nodal pattern are observed as nodes and anti-nodes sweeping across the auditorium. Music is then played to demonstrate how a large number of frequencies played simultaneously give rise to a "washing out" of the nodal pattern.

The fact that the nodal lines in the interference patterns formed by a single frequency sound are not totally "dead" leads naturally to a discussion of virtual sound sources. These virtual sources result from multiple reflections from the walls, ceiling and floor of the auditorium. If time permits, a single speaker and a large wood panel are used to set up an interference pattern. The wood panel serves as reflector and hence a virtual source of sound. The interference pattern formed by a real source and its image is easily observed.

The auditorium is also the perfect place to observe how the color of an object depends on the color of the incident light. We have all the students come up on the stage and observe the color of their clothing under white light. Then the white light is turned off and each primary color is used in turn to illuminate the stage and its occupants. The reaction of the students is truly amazing!

Electrical Circuits Using People as Conductors

Although the resistance of dry skin is very high (~ 500,000 Ω), a tiny, yet detectable current (about a millionth of an amp) will flow through the body with the application of only a few volts. The UFO Ball is a device capable of producing and detecting such a current (Fig. 2). Inside the UFO Ball is a small printed circuit board containing two 1.5-V batteries, a three-transistor amplifier, a small light bulb, and a sound source.

Figure 2. The UFO Ball

When fingers are placed on the two metallic contacts on an UFO Ball, the ball flashes and a tone is produced. This indicates that a current is flowing through your fingers and a portion of your hand. If either finger is removed, the circuit will be broken and the UFO Ball will cease to function.

The UFO Ball may be used to demonstrate series and parallel circuits. To form a series circuit, two or more students hold hands to form a chain (Fig. 3). The UFO Ball will be activated when the two students at the end of the chain each touch a contact on the ball. If the circuit is broken at any point, the ball will stop functioning. There doesn't appear to be any limit to the number of students that can be in the circuit.

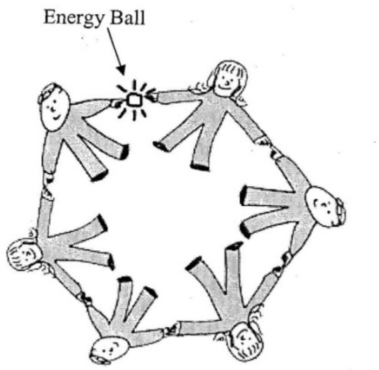

Figure 3. Students forming a series circuit

Two parallel lines of students bridged by students in between may be used to form a parallel circuit (Fig. 4). The UFO Ball will continue to flash and produce a tone if one, or even two, of the bridging students shown in the figure drop out of the circuit.

Figure 4. Students forming a parallel circuit