Traveling waves on a rope

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question, "What color is deviated most?" elicited 80% of correct responses. The responses "green," "orange," "tan" might indicate deficiencies in color vision. About 50% of the students answered correctly the question, "If there are more lines/cm in the grating, would you see more, fewer, or the same number of spectra?"

The exercise enabled high school physics students to (1) apply the concept of diffraction; (2) determine the limits of their color perception; (3) learn how to measure wavelength with simple apparatus; (4) observe continuous and line spectra; (5) associate colors with corresponding wavelengths.

A post–lab discussion of the class data would most likely reinforce the learning outcomes of this exercise. It would also be desirable to display on the classroom bulletin board histograms and other data summaries.

We wish to acknowledge a most helpful assistance by William Merrow.

Reference

1. Available from Edmund Scientific, Cat. #50,201 in sheets 8½ x 11 in. at $3.95. Also in 35-mm cardboard mounts, Cenco Cat. #86,252-30 at $32.50 per package of 25.

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Propagation of a wave in one dimension is readily demonstrated on a rope under tension. The usual procedure is to attach one end rigidly, then pulling on the other end to provide tension (and at the same time keeping the rope reasonably horizontal), one gives a vertical flip and observes a pulse travel down the rope. Almost any rope will work if not too stiff; I have even made do with the power cord of an overhead projector.

One readily discovers, if one didn't know already, that the pulse is reflected from the fixed end and travels back toward the hand with reversed amplitude. While this reflection may be interesting in itself, it is rather a nuisance if one wishes to demonstrate the propagation of a continuous sinusoidal wave or "traveling" wave. The reflected wave is superimposed on the transmitted wave, and what one actually observes is a standing-wave pattern of nodes and antinodes. Although one can easily prove mathematically that a standing wave is the sum of two traveling waves, the fact remains that one does not *observe* a traveling wave.

Using a longer rope doesn't help much. To avoid excessive sag under its own weight, one must increase the tension, which in turn increases the speed of the waves, and the wave arrives at the fixed end just as quickly as for a shorter rope. The ideal "infinitely long" rope often shown in textbook diagrams is difficult to approximate in the laboratory.

Here is a simple method to show real traveling waves. Using a flexible rope about 8 to 10 m long, tie one end to a table leg *near the floor*. Apply a tension at the other end of the rope to keep it fairly taut, and hold the end just high enough above the floor so that about one quarter of the rope lies along the floor, and the rest is suspended in air. The floor should be quite smooth, such as tile or wood, but not carpeted. Now at the hand-held end apply a sinusoidal transverse motion in a *horizontal* plane. Waves travel down the suspended portion of the rope and are then damped out progressively in the portion lying along the floor, thus eliminating any reflected wave. A little experimentation will soon determine a suitable combination of tension and hand height above the floor. A rather vigorous motion of the hand is required since it must move through the full amplitude of the wave. In comparison, for standing waves, a small hand motion produces large amplitude because of resonance.

This demonstration nicely illustrates the propagation of energy in a wave. The source of the energy will be readily apparent to the person providing the aforesaid vigorous motion. The energy then propagates along the rope and is converted to thermal energy as the rope moves against friction on the floor.

I actually discovered this demonstration in a playground. Some kids were playing a game called "rattlesnake," in which one produced the kind of rope waves just described, and the others had to jump back and forth across the "snake" without getting "bitten." Might be a good way to introduce the subject.