

INTRODUCTION TO WAVES EXERCISE

Objectives: To introduce students to basic terminology used in reference to periodic waves, to give students an understanding of how wind energy is transferred into wave energy.

Materials required: Hand-held hair dryer, 9x13 inch clear glass Pyrex pan or a large cookie sheet with at least 1/4 inch sides, pitcher of water, ruler, and paper towels for cleaning up. A water soluble overhead projector marker may also be useful.

Introduction: Ocean waves are described using the same terminology that students may have already learned in physics classes for description of periodic waves. The *crest* is the highest part of the wave, the *trough* the lowest part of the wave. The *wave height* is the vertical distance between the crest and nearest trough. The *wave length* (L) is lateral distance between two troughs or two crests. The *wave period* is the amount of time that it takes for two successive wave crests or troughs to pass a fixed point. The *frequency* is the number of waves per second, which is the inverse of the period (frequency = $1/\text{period}$). The velocity of the waveform or *celerity* is calculated by dividing the wavelength by the wave period. (celerity = wavelength/period in seconds).

As waves pass over deep water, individual water molecules move in nearly stationary circular motions. At the surface, the diameter of the orbits is approximately equal to the wave height. Below the surface, the size of the orbit of a given water molecule decreases downward through the water column to a depth of $L/2$, below which there is no motion of water related to the wave. In water less than $L/2$ deep, the bottom distorts the orbits of the water molecules. The effects of this phenomenon will be covered in a subsequent lesson.

The crests of waves are visible at the surface. Just as a rock thrown into a puddle will produce waves moving outward, wind will produce linear wave crests moving across a body of water. Crests of waves can also be *refracted* or bent by irregularities of the ocean floor or offshore structures. In the experiment described here, waves are *reflected* back from the sides of the pan.

Most ocean waves are generated by wind blowing over the surface of the water. The size of waves depends on wind speed, the length of time that the wind blows in a consistent direction, and the *fetch*, which is the distance over which the wind blows. Essentially, the stronger the wind and the longer it blows, the larger the waves become. Through this process, a tremendous amount of energy is imparted to waves. The ultimate source of this energy is the sun, and it is this energy that moves tremendous volumes of sediment.

Activities: 1) Introduction to terminology used to describe waves. This portion of the lesson should take about 10 minutes and should give students a greater appreciation of what they will see in the experiment. 2) Active participation by students in experiment. This portion of the lesson will probably take less than 20 minutes and will allow students to apply the vocabulary terms they have just been taught and to discover for themselves

the processes that create waves. 3) Review and discussion of wave shape, refraction, transfer of wind energy to wave energy. This portion of the lesson should last at least 10 minutes. The teacher can guide the students through interpretation of their observations, reinforce their knowledge of terminology used in association with waves, and give them a greater level of understanding of the role of solar heating and wind energy in creation of waves along the coast.

Experiment Designed to Promote Discovery-based learning: Students should work in teams. Fill a Pyrex pan with water no more than 1/2 inch deep or a large cookie sheet until the water comes about half way up the sides of the pan. Students may be able to create waves by physically blowing across the surface of the water. It is also possible to create waves using a hair dryer. Hold the hair dryer, set at a “low “ setting, about six inches away from the edge of the pan and allow the air to blow across the surface of the water at a low angle. Waves will form on the surface of the water and, depending on where the hair dryer is held, can be seen in cross section on the side of the pan. If students are using a Pyrex pan, ask one of them to try marking the wave height on the side of the pan using an overhead projector marker and measure it using the ruler. This may prove challenging as the frequency will be rapid. The students may be more comfortable making a visual estimate of wave height using a ruler. Students should attempt to estimate the wavelength using the ruler as well. In either case the goal is for them to identify and observe wave height and length, the actual measurement itself is of little consequence.

In our experience, when the hair dryer was held closer to the edge of the Pyrex pan we created waves that were easier to measure. When we allowed the hair dryer to blow down the center of a large cookie sheet we were able to observe refraction of waves off the edges of the pan.

Suggested Homework: Prepare a diagram labeling wavelength, wave height, amplitude, crest, and trough. Extra credit: prepare a diagram to illustrate frequency and period.

