# Simulate Interference … While Supplies Last

**David Chandler,** Porterville High School, 465 W. Olive, Porterville, CA 93257, david@davidchandler.com

Interference patterns are a thing of wonder! They have to be seen to be believed. All students should see interference patterns for themselves through several methods — in a ripple tank, looking through a gap in their fingers or a Vernier caliper at a narrow light source, and shining a laser through a mask with various slit configurations to project interference patterns onto the wall. Of course simulations should never replace the real thing, but once the actual phenomena have been experienced, simulations can make the analysis more concrete.

Some years ago I saw a double-slit interference simulation at the Exploratorium in San Francisco that made use of two chains bolted near the top of a wide board. Bringing the chains together at different angles illustrated how the links could meet "in phase" or "out of phase." I made a board like this for my physics class, but then I saw an easier way to achieve the same results with a simple make-and-take apparatus.

- Find (and hoard) a large box of old-fashioned pin-feed computer paper with removable edge strips before this product becomes totally obsolete and unavailable. Pass out two sheets to each student.
- Remove the edge strips. Each student should have two pairs of strips. Each student also needs at least two sheets of graph paper, two pushpins, and a rectangular piece of cardboard, corkboard, or other suitable backing.
- Have each student draw wavy lines down two of the strips, going over the first hole, under the second, and so on. This is the long-wavelength pair with $\lambda$ = two hole spacings. The holes are ½ in apart, so $\lambda$ = 2.54 cm. Make sure both strips are constructed in phase.
- For the second pair of strips, draw wavy lines by going over each hole and dipping down and back between adjacent holes. This is the short-wavelength pair with $\lambda$ = 1.27 cm.
- Draw a line down the center of a sheet of

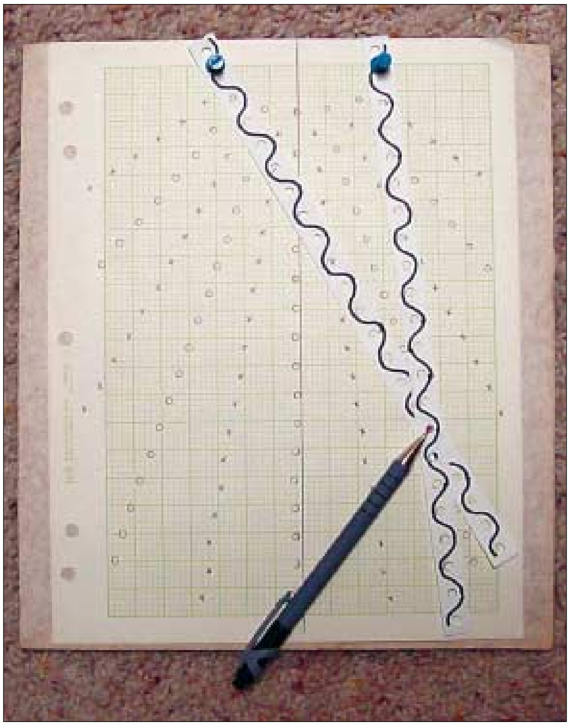

**Fig. 1. Photograph shows a completed set of nodal and antinodal lines created by aligning the holes of two pin-feed strips. Antinodes are marked with circles; nodes are marked with x's. The variation of pattern spacing with source separation can be studied by this method. Wavelength can also be changed to other multiples of the ½-in hole spacing.**

graph paper and define two source points or "slits" a distance $d$ apart, symmetric about the center line near the top of the sheet. (To save time you might want to assign different $d$'s to different groups of students.) Pin a matching pair of strips at these points, piercing the strips halfway between two holes, being careful to keep them precisely "in phase."

- Trace lines of antinodes by finding all the places where the holes from the two strips line up with the waves in phase. Line up the holes carefully and trace them with little circles. Note, from the method of construction, that each antinodal line satisfies the formal definition of a hyperbola. Draw the asymptote to each antinodal line from the midpoint between the two pins and verify the equation $d \sin\theta = n\lambda$, where $d$ is the slit spacing and $\theta$ is the angle from the central axis to the asymptote.
- With the long wavelength pair of strips, students can trace the lines of nodes as well, where the waves meet 180° out of phase. Mark them with x's instead of circles and verify that $d \sin\theta = (n + \frac{1}{2})\lambda$.
- Count the number of antinodal lines on one side of the central axis and compare with the ratio $d/\lambda$. (Tall push-pins may interfere with tracing the last nodal/antinodal line near $\theta = 90°$.) Change $d$ and repeat, or compare with the work of other groups of students who were assigned different $d$'s.
- Note that as $d$ increases, the spacing of the nodal and antinodal lines decreases. This is initially counterintuitive for most students.
- Post examples with a progression of $d$'s so all students can compare results.

The primary value of this simulation is qualitative. The tactile process of constructing the pattern makes the geometry come alive, and the inverse variation of the pattern spacing with slit separation is dramatic and immediate. However, the quantitative results of the exercise are quite satisfying as well. I remember from my own experience as a high school student being bothered by the derivation of a formula in which two lines that clearly meet are assumed to be parallel! Despite the crudeness of the "parallelism" on the scale of this exercise, $\theta$ derived rigorously from the geometry of the problem differs from the result given by $d \sin\theta = n\lambda$ by less than 0.5% for the case $d = 2$ in and $n = 1$. Agreement between the "approximate" formulas and practical results is easy to achieve within a few percent with reasonable care.

etcetera...

## Accident Report

"A former ... County Commissioner who was injured and lost his barn in an explosion is suing a gas company, claiming an employee overfilled propane cylinders ... [the victim] said the blast occurred after a new gas-company employee filled propane tanks he used for his part-time barbecuing business. The employee was supposed to fill a 300-gallon tank, but instead overfilled two 40-pound propane cylinders, creating pressure that eventually escaped and was ignited by the pilot light on the barbecue, according to the lawsuit."[1]

The question is, "Can you overfill a propane cylinder?" To understand the important physics involved, you must think of the Triple Point Diagram for propane to see what phase it is in when it is under pressure in a cylinder. A related question is,"Why are there generally no pressure gauges on propane cylinders?"

1. "Ex-commissioner sues over propane explosion," *Daily Camera* (Boulder, Sept. 6. 2000), p. 6C.

**A²B**