Transverse Wave String

P7-1500-03

INSTRUCTIONAL GUIDE

Contents

- 7-foot elastic string
- String holder
- Hook holder
- Allen Key

Required for Activity:

- Sine Wave Generator (P7-2000)
- Mechanical Wave Driver (P7-1000)
- Table Clamp Pulley (P1-6115)
- Hooked Mass Set of 9 (91-1000)
- Ring Stand Base with Rod (66-4220)

Background

Wave interference occurs when two longitudinal waves interact and either constructively increase amplitude or destructively decrease amplitude. The observed overlapping appearance is called an interference pattern. For instance, when formed along a one-dimensional rope or spring, this can produce a pattern called a standing wave. Tie a rope to a wall and shake it and the wave reflected from the wall will come back and interfere with the following waves moving toward the wall. At the right frequencies, nodes will form where the interfering waves cancel out and anti-nodes will form where the waves create larger amplitudes.

Introduction

An impressive demonstration of standing waves on a string for your students is easily produced in the classroom using the **Mechanical Wave Driver** along with the **Sine Wave Generator**. Going further, the students can directly measure the length of the waves from the standing wave pattern and confirm the wave equation $v=\lambda f$ using the frequency value from the Sine Wave Generator. With the wavelength and the frequency, the speed of the waves along the string can be calculated. Later this speed value can be compared to theoretical speed calculated from the physical properties of the medium (string).

Activity

Set up:

1. Fasten the neon red string to a fixed post or ring stand making sure it is slightly higher than the Mechanical Wave Driver.
2. Thread the string through the hole in the string holder inserted in the Wave Driver.
3. Fasten the **Table Clamp Pulley** on a ring stand approximately 2 meters from the string holder.
4. Thread the string over the pulley making sure it is clear of the table and attach a **hooked mass**.

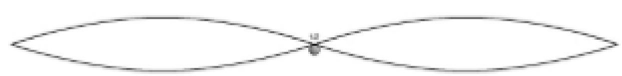
Your students will use the wave equation $v=\lambda f$ to calculate and predict the speed of the waves traveling back and forth along the string. After the apparatus is set up as shown below, the frequency and amplitude of the driver can be adjusted to produce standing waves with maximum amplitudes.

Observations

Measuring wave speed along the string: Start at a low frequency and slowly increase the value through turning the frequency nob. The frequency which produces the longest standing wave is called the fundamental and has the appearance as shown in the diagram below.

Fundamental

At this lowest standing wave frequency, called the fundamental, the length of the standing wave is twice the length of the string. The fixed ends of the string are points called nodes and the center of the string, where the string moves up and down with maximum amplitude is called the antinode. Now increase the frequency until the next standing wave appears. This should occur at a frequency twice the value of the fundamental frequency and is known as the second harmonic. As shown below, there should now be two antinodes formed.



2nd Harmonic

The distance from antinode to antinode or from node to node is half a wavelength. Have the student measure and record either of both of these lengths. If both are measured, average their value and multiply it by two to get the wavelength. From the display on the Sine Wave Generator record the frequency producing this standing wave.

frequency (2nd harmonic) _________ Hz Wave length __________ m

Calculate the wave speed from the wave equation showing the substituted values:

v = (   ) x (   ) = _______ m/s

Now, increase the frequency of the generator to produce standing waves of higher frequency and shorter wave length. If the length of string and tension have not been changed the wave speed should remain relatively constant. Using the same procedure above, measure and calculate the wave speed again.

Within the uncertainty of measurements, how do these new values compare?

Going Further

The speed of the waves on the string in the above experiment is determined by the physical characteristics of the string. That is, the string density μ (M/L) in kg/m and the string tension (T) in Newtons.
The equation that relates these values is:

$$v = \sqrt{\frac{T}{\mu}}$$

The string tension (T) is produced from the weight of the hanging mass as explained in the Activity Set up. For instance, if a 100 g mass (0.1 kg) is used, the tension represented by "*mg*" would be 0.1 kg x 9.8 m/s^2 = 0.98 N. For the linear string density, measure the mass (m) of the string and divide it by its length (L). Record these values below.

T = ___________ N m = ___________ kg L = ___________ m

Now calculate the Wave Speed from the equation for wave speed:

$v = \sqrt{\frac{T}{\mu}}$ = __________________ m/s

How does this speed compare to the speed obtained using v=fλ?

Related Products

Standing Wave Kit (P6-7700) Perfect for middle school and high school students, this kit includes all the materials you need to make 10 standing wave demonstrations. Instructions include qualitative and quantitative experiment ideas.

Spring Wave (P7-7220) Use this highly visible Spring Wave to observe phase reversal at the fixed end of wave pulses and to test fundamental and multiple vibrations.

Helical Spring (33-0140) 2cm diameter, 180cm long (collapsed) helical spring. "Snaky" is ideal for demonstrating fundamentals of wave theory, including transverse and longitudinal waves and wave behavior at the interface of two media.