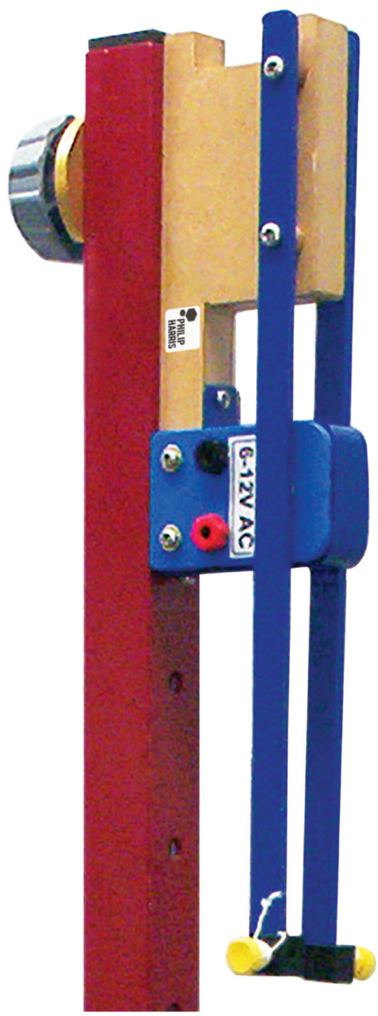
Foundation Physics



Electric Tuning Fork

Electric Tuning Fork

KIT CONTENTS

ITEM	QUANTITY	DESCRIPTION
1	1	Electric Tuning Fork
2	3	Mounting Bolts
3	2	Holding Clips
4	1	Spring
5	1	Instructions (this booklet): Teacher's Guide: pages 2 - 4 Student Guide (reproducible): pages 5 - 10

Additional Materials Required:
'Foundation Physics Stand'
Power Supply, 12 V AC
Meterstick
String
Various Hanging Masses (50 g, 100 g, and 200 g)

OVERVIEW / SUGGESTIONS FOR USE

The electric tuning fork allows students to easily study standing waves and some of their properties.

Activity 1. Standing Waves - KS3 KS4 and A-Level
Students investigate transverse and longitudinal waves.

Activity 2. Velocity of a Wave - Higher KS4
Students calculate the velocity of the standing wave and analyze how the tension in the string affects the standing wave.

CLASS TIME REQUIRED

(1) 40-minute period

YEAR GROUP

Grades 7 - 11

NATIONAL CURRICULUM STANDARDS

Content Standards	Grades 7 - 11
B. Physics	• Observed waves • Energy • Waves • Wave motion

TEACHER PREPARATION (PRIOR TO CLASS)

Read through the student activities and make copies of pages 5 - 10.

Set up a Universal Stand, electric tuning fork apparatus, power supply, and other materials needed.

TEACHER ANSWER GUIDE

The answers provided below are sample data; the student's findings may vary.

Activity 1: Standing Waves

A. Transverse Waves

Questions:

1. How do different masses hanging from the strings affect the standing waves?
   As larger masses are used, the number of standing waves decreases.

2. Draw a picture of the waves that you see and identify the parts of the waves (node, antinode, wavelength).
   See Diagrams in Student Guide page S1.

3. Predict how the standing wave would change if a 200-gram mass were put in place of the 50-gram mass. Replace the 50-gram mass with a 200-g mass and readjust the length of the string until a standing wave is created. Compare this to your prediction.
   The prediction should be that the wavelength will increase with a heavier mass. Adding a large mass should reflect this.

B. Longitudinal Waves

Questions:

1. Compare the waves produced when different amounts of force are used to pull the spring.
   The position and number of the compressions and rarefactions do not change. Only the distance between these parts varies.

2. Identify the different parts of the wave in your drawing (compression, rarefaction, and wavelength).
   See Diagrams in Student Guide page S2.

Activity 2. Velocity of a Wave Sample Data

Data Table 1

Mass on String A = 50 g		
Wavelength ( )	Frequency (Hz)	Velocity (m/s)
0.60	*60*	*36*
0.61	*60*	*36.6*
0.59	*60*	*35.4*
Average:		*36*
Mass on String B = 100 g		
Wavelength ( )	Frequency (Hz)	Velocity (m/s)
0.80	*60*	*48*
0.80	*60*	*48*
0.80	*60*	*48*
Average:		*48*

Questions:

1. Explain how the wavelength for each string changed as the hanging mass varied.
   As a larger mass was placed on the string, the wavelength increased.

2. Based on your experiment, explain the relationship between the wave velocity and the mass hanging on the end of the string.
   A wave will travel faster through a string that has a heavier mass hanging on it.

Electric Tuning Fork

STUDENT GUIDE

BACKGROUND

A transverse wave is a vibratory disturbance in which the direction of the wave is perpendicular to the motion of the molecules. See Figure 1. Light is an example of a transverse wave.

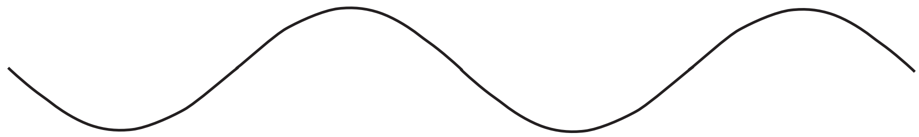


Figure 1: Transverse Wave

A longitudinal wave is a vibratory disturbance in which the direction of the wave is parallel to the motion of the molecules. See Figure 2. Sound is transmitted through gases, plasma, and liquids as transverse waves. However, sound can be transmitted through solids as both longitudinal and transverse waves.

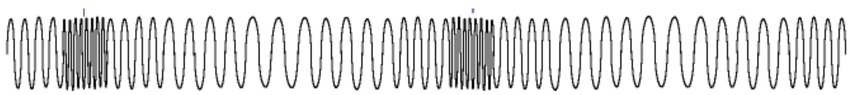


Figure 2: Longitudinal Wave

The parts of a wave are labeled in Figure 3 and Figure 4, below.

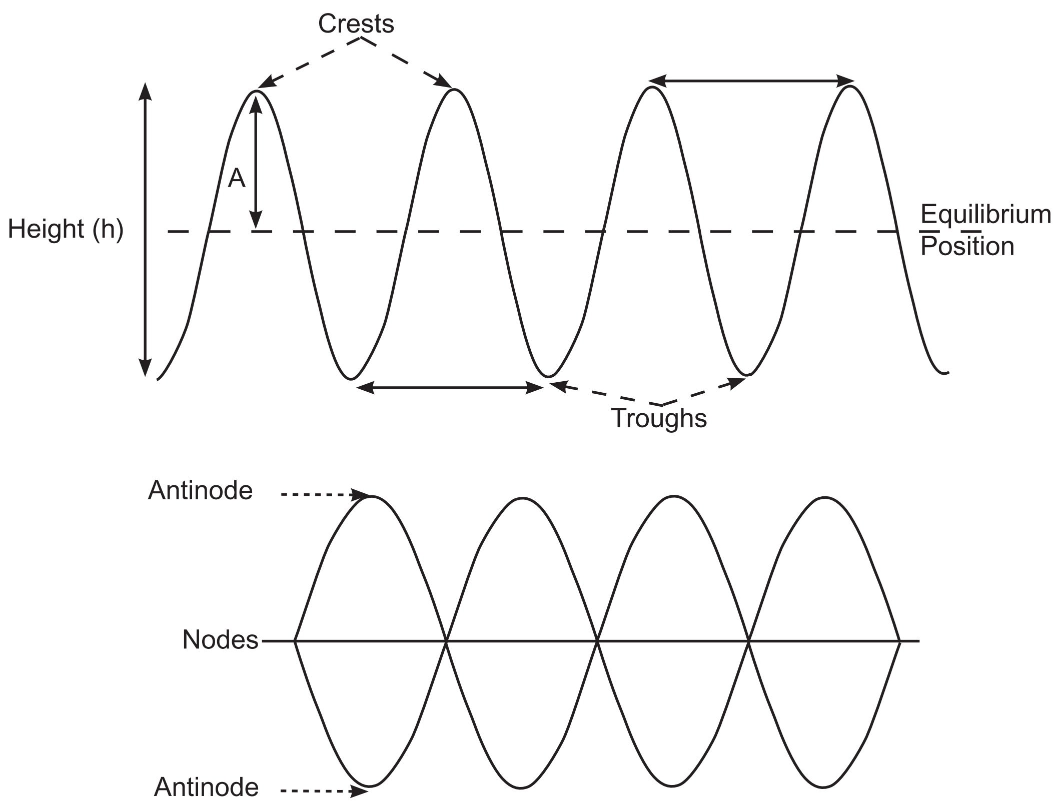


Figure 3: Parts of a standing transverse wave

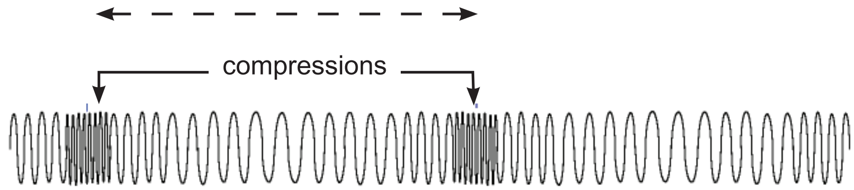


Figure 4: Parts of a standing longitudinal wave

The frequency, velocity, and wavelength of a wave are interrelated. This can be expressed by the equation:

$$v = f$$

The frequency of the electric tuning fork is provided by the AC voltage. The frequency of AC voltage varies by country. In the USA, electricity is supplied with AC voltage at 60 Hz. If using a different source for the AC voltage, the frequency can be determined with a stroboscope. Once a standing wave is established, the wavelength can be easily measured with a meterstick. A standing wave is the combination of a wave and a reflected wave of equal amplitude and wavelength.

The type of string used can affect the velocity of the wave. For consistency, the same type of string should be used in each experiment or trial run.

Key Words

Crest: Top of a wave.

Trough: Bottom of a wave.

Amplitude (A): Distance from the equilibrium position to the crest or trough.

Height (h): Distance from crest to trough.

Wavelength (Distance from crest to crest or from compression to compression.

Node: Position of minimum displacement (no movement).

Antinode: Position of maximum displacement.

Frequency: Number of waves that pass by a given point each second.

Compression: Region of maximum density for a longitudinal wave.

Rarefaction: Region of minimum density for a longitudinal wave.

ACTIVITY 1: STANDING WAVES

Materials Needed:
Electric tuning fork
Mounting bolt
Holding clips
Spring
Foundations of Physics Universal Stand
String - 2 pieces, each about 1 meter long
Hanging masses (50 g, 100 g, and 200 g)
12 V AC power supply

Procedure:
A. Transverse Waves

1. Connect the electric tuning fork to the top hole on the Foundations of Physics Universal Stand, keeping the blue bars vertical and pointing downward.
2. Attach a mounting clip to the lower end of one blue bar. Leave a small space between the front of the bar and the front of the clip. Thread a string through this space. See Figure 5.
3. Tie a loop at the lower end of the string. Hang a 50-g mass through the loop.
4. Repeat the process with the other bar of the tuning fork, using a 100-g mass.
5. Connect a 12 V AC power supply to the electric tuning fork.
6. Turn on the power supply and slowly raise or lower the masses on the strings until a standing wave is created for each mass.
7. Once a standing wave is created, wrap the string around the set screw to hold it securely. See Figure 6.
8. Once both strings are secured, turn off the power supply.
9. With both strings and masses still securely attached, turn on the power supply and answer the questions below.
10. When the questions are answered, shut off the power supply.

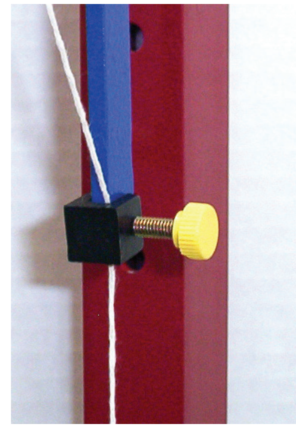


Figure 5

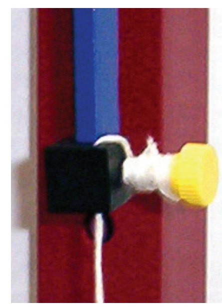


Figure 6

Questions:

1. How do different masses hanging from the strings affect the standing waves produced?

2. Draw a picture of the waves that you see and identify the parts of the waves (node, antinode, wavelength).

Activity 1: Standing Waves (Continued)

3. Predict how the standing wave would change if a 200-gram mass were put in place of the 50-gram mass. Replace the 50-gram mass with a 200-g mass and readjust the length of the string until a standing wave is created. Compare this to your prediction.

Procedure:

B. Longitudinal Waves

1. Set up the apparatus with one mounting clip and the spring, as shown in Figure 7a and Figure 7b.
2. Connect a 12 V AC power supply to the electric tuning fork.
3. Turn on the power supply and gently pull down on the free end of the spring.
4. Experiment by pulling with different amounts of force to see if it changes the wave.
5. Draw the pattern you see in the space below.

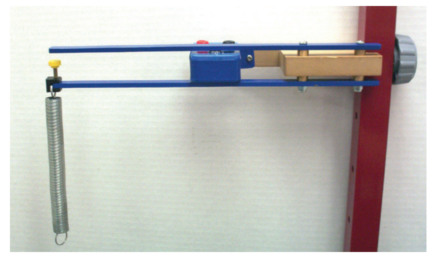


Figure 7a

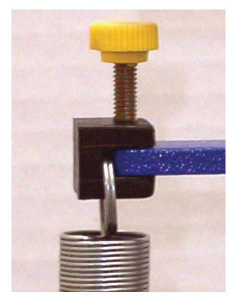


Figure 7b

Questions:

1. Compare the waves produced when different amounts of force were used to pull the spring.

2. Identify the different parts of the wave in your drawing (compression, rarefaction, and wavelength).

ACTIVITY 2: VELOCITY OF A WAVE

Materials Needed:
Electric tuning fork
Mounting bolt
Holding clips
Spring
Foundations of Physics Universal Stand
String - 2 pieces, each about 1 meter long
Hanging masses (50 g, 100 g, and 200 g)
12 V AC power supply
Meterstick

Procedure:

1. Follow the procedure for Activity 1A: Transverse Waves (p. S3). Establish two standing waves with two different masses, referred to in Data Table 1 as string A and string B. Record the mass on each string.
2. Use a meterstick to measure the wavelength of the standing wave. Remember, the wavelength can be found by doubling the distance from one node to another. Make three measurements of this distance to minimize errors. Record the wavelength for each string in Data Table 1.
3. Record the frequency of the wave in Data Table 1. This is the frequency of the AC power supply (60 Hz in the USA). Frequency can also be determined with a stroboscope.
4. Calculate the velocity of the wave by using the equation $v = f$
5. Calculate the average wave velocity for each string.
6. Repeat steps 1 - 5 using different masses. Two masses can be hung on one of the strings. Record the masses and your findings in Data Table 2.

Data Table 1

Mass on String A = ____ g		
Wavelength (λ)	Frequency (Hz)	Velocity (m/s)
Average:		
Mass on String B = ____ g		
Wavelength (λ)	Frequency (Hz)	Velocity (m/s)
Average:		

Activity 2: Velocity of a Wave (Continued)

Data Table 2

Mass on String C = ____ g		
Wavelength ( )	Frequency (Hz)	Velocity (m/s)
Average:		
Mass on String D = ____ g		
Wavelength ( )	Frequency (Hz)	Velocity (m/s)
Average:		

Questions:

1. Explain how the wavelength for each string changed as the hanging mass varied.

2. Based on your experiment, explain the relationship between the wave velocity and the mass hanging on the end of the string.

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