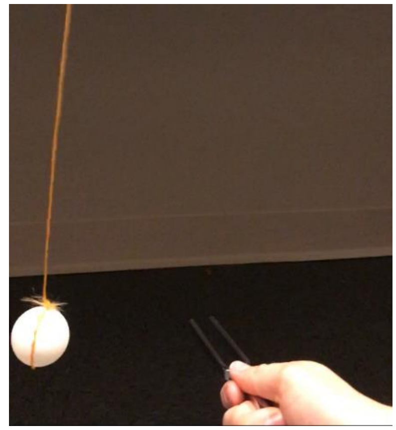
Tuning Fork with Pendulum

Demonstration

Watch the energy transfer from a tuning fork into a ping pong ball pendulum.



Number of Participants: Unlimited

Audience: Elementary (ages 5-10) and up

Duration: 5 -10 mins

Difficulty: Level 1

Materials Required:

- Tuning fork
- String (~1 m)
- Ping pong ball
- Stand or other means of supporting a pendulum

Setup:

Figure 1 Materials needed for demo, minus the pendulum stand.

1. Gather the materials shown in Figure 1. Tie a knot around the ping pong ball with the string at one end. Hang the other end of the string on a stand or comparable structure to make a simple pendulum.

2. Hold a vibrating tuning fork right next to the equilibrium position of the pendulum. When the ping pong ball touches the vibrating tuning fork arms, it will start to bounce with a large amplitude, relative to the small motion of the tuning fork arms.

Presenter Brief:

Understand sound waves, energy, conservation of momentum, and simple harmonic motion.

Vocabulary:

- Simple harmonic motion – repeating motion of a simple oscillating system.
- Frequency – the rate of vibration. Measured in hertz, or cycles/second.
- Conservation of energy – the law that states that energy can't be created or destroyed, only changed from one form to another.

Physics & Explanation:

Middle (ages 11-13) and general public:

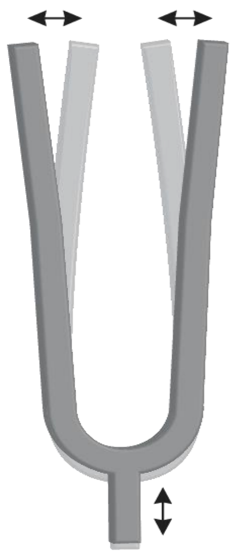


Figure 2 The vibrational motion of a tuning fork.

Tuning forks make sound waves by pushing air back and forth at their resonance frequency, by naturally oscillating in a simple, back and forth way many times per second, as shown in Figure 2. This causes small regions where the air is more and less dense, or waves. These waves travel through air and we can hear them as sound. Our ears function as detectors for sound waves, detecting frequencies between 20 Hz and 20 kHz.

All of this is very hard to see, mainly because the rapid movement and small movement of the fork arms. But we are lucky because all waves, including sound waves, carry energy. By placing the vibrating tuning fork next to a light hanging object such as a ping pong ball, vibrational energy of the tuning fork will transfer into the ping pong ball – causing the ping pong pendulum to start swinging with simple harmonic motion.

Waves are energy carriers.

A very important physics question is, "Why does the ping pong ball move so much in comparison to arms of the tuning fork?" The easiest explanation for this apparent difference in motion is the laws of conservation of momentum and conservation of energy. On one hand, the tuning fork is moving a small distance very rapidly, but the fork is relatively massive. When the less massive ping pong ball makes contact with the tuning fork arm, it is rapidly accelerated with only a small amount of energy from the tuning fork.

🔑 The very light ping pong ball only needs a little energy from the tuning fork to get a large velocity.

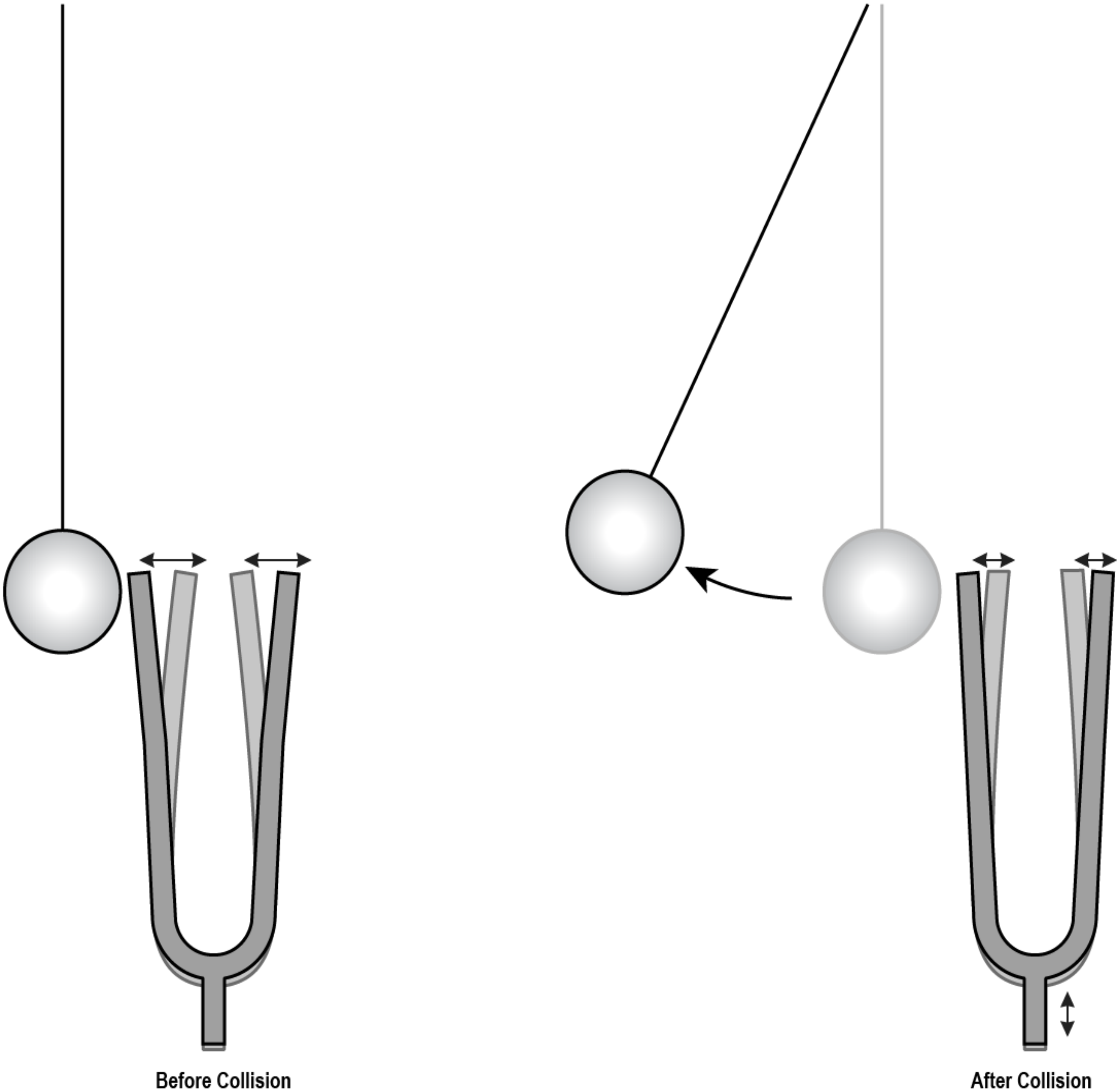


Figure 3 Before colliding, the tuning fork arms are rapidly moving, with large amplitude vibrations. Upon contact, energy is transferred to the ping pong ball, and the tuning fork arms vibrate with less amplitude.

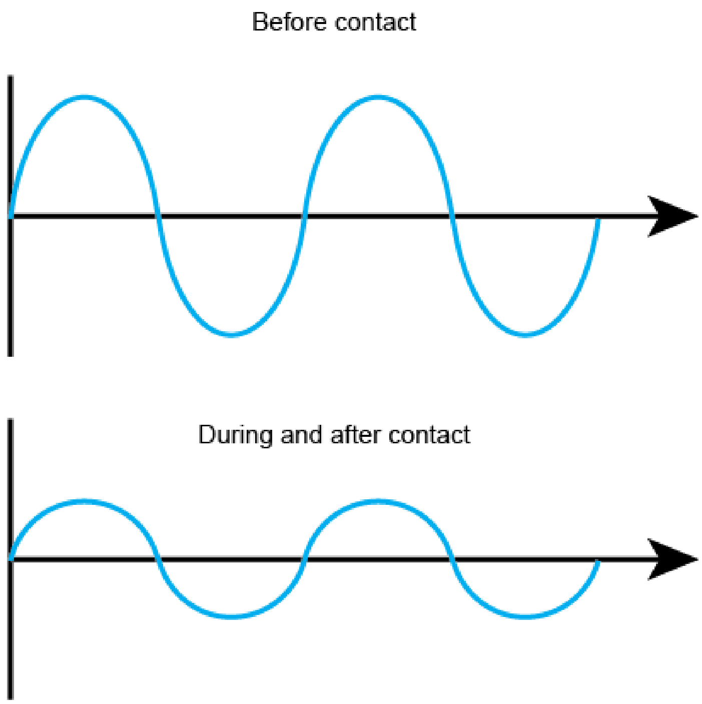


Figure 4 Frequency and amplitude of the tuning fork as a function of time, before and after contact with the ping pong ball.

After contact with the ping pong ball, the amplitude of the tuning fork vibrations dampen. Amplitude is another way of counting how much energy is in the system. As time goes by, the tuning fork loses amplitude by transferring it to the ball, and through loss to the surroundings. As expected, frequency is only determined by the geometry of the tuning fork, staying constant with time.

Additional Resources:

- Rossing Moore & Wheeler *The Science of Sound* 2002. (p. 33-34)
- Resnick, Halliday, Walker *Fundamentals of Physics,* 2001. (p. 347)