

# Lesson Plan

**Description**  
 Waves around us. Even if we cannot see them, their properties help us see, hear, transmit information and much more. This lesson will explain more about the nature of waves, their properties, and areas of application. You will program a device that will use their properties to find objects and measure distance. You will learn how such devices are used and will code them. You will be using Tinkercad.

- Learning Outcomes**
- Students will conduct an interactive investigation of frequency, wavelength, and period.
  - Students will consider such concepts as interference and diffraction, observe the conditions under which they occur, investigate the process.
  - Students will get acquainted with electronic elements and learn about an electric circuit.
  - Students will be able to create a virtual circuit and emulate and code the operation of a real device.
  - If the equipment is available, students will be able to reproduce the emulated device from real components and integrate it into their own ideas.

**Specific Expectations**

**E2.1** use appropriate terminology related to mechanical waves and sound, including, but not limited to *longitudinal wave, transverse wave, frequency, period, cycle, amplitude, phase, wavelength, velocity, superposition, constructive interference, destructive interference, standing waves, and resonance.*

**E2.2** conduct laboratory inquiries or computer simulations involving mechanical waves and their interference

**E2.4** investigate the relationship between the wavelength, frequency, and speed of a wave, and solve related problems.

**E3.** demonstrate an understanding of the properties of mechanical waves and sound and of the principles underlying their production, transmission, interaction, and reception.

**Introduction**

**1. Sound sources and receivers**

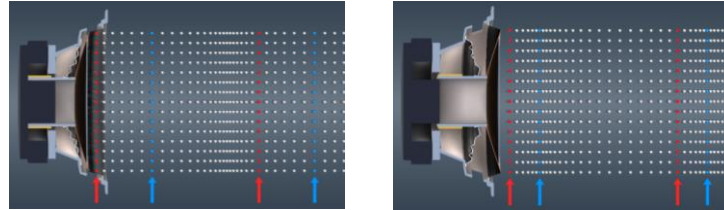
Why, when we pull the free end of the ruler pressed to the table, do we hear a sound?

Oscillations of the ruler cause thickening and rarefaction of air and, as a result, periodic increases and decreases in pressure in the oscillation zone. Compressed air, trying to expand, presses on neighbouring layers, also squeezing them. So, from the ruler in all directions begins to spread a longitudinal mechanical wave, which eventually reaches your ear. The air



pressure near the ear membrane changes periodically, and the membrane begins to oscillate. The end of the line oscillates with a frequency of more than 20 Hz, it is with this frequency that the ear membrane begins to oscillate, and oscillations with a frequency of 20 to 20,000 Hz are perceived by a person as sound.

**Sound is a physical phenomenon, which is a mechanical wave with a frequency of 20 to 20,000 Hz.**



**Sound sources are various bodies oscillating with a frequency of 20-20,000 Hz.** (Headphone membranes and strings of musical instruments, loudspeaker diffusers and insect wings, machine parts)



**Sound receivers are bodies in which sound signals are converted into other signals so that sound can be perceived and analyzed.** (Organs of hearing of humans and animals – in these organs sound (mechanical) vibrations are converted into nerve impulses. Microphone – sound vibrations are converted into electrical ones)

## 2. The speed of sound propagation

Why is thunder heard later than a flash of lightning? (Sound waves travel at a finite speed much lower than the speed of light; at 20°C, the speed of sound in air is approximately 340 m/s.)

**The speed of sound propagation depends on the density, elasticity, temperature, composition, and other characteristics of the medium.**

Approximate values of the speed of sound propagation in some environments

Environment	V, m/s
Water	1500
Hydrogen	1250
Iron, steel, cast iron	5000
Air	340
Glass	4500

Why is the speed of sound propagation in hydrogen greater than in air, and greater in steel than in water? (The denser the elastic medium, the greater the speed of sound.)

Why is it impossible to hear the roar of rocket engines in space? (In a vacuum, sound does not propagate, because there is no medium whose particles can oscillate.)

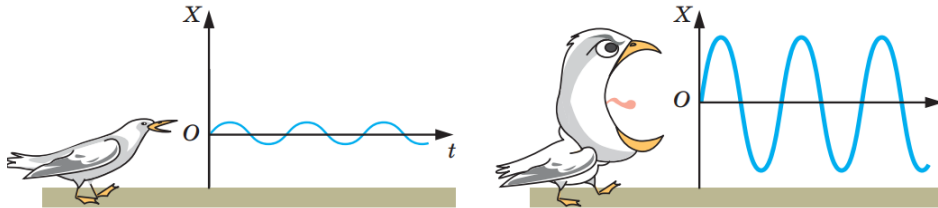
## 3. Sound characteristics

**Tone of sound:**

The higher the frequency of the sound, the higher the tone of the sound, and vice versa. (High loot of mosquito, low tone of cow mooing)

**Sound volume:**

The larger the amplitude, the louder the sound.



**4. Sound reflection**

**An echo is a sound reflected from a distant obstacle.**

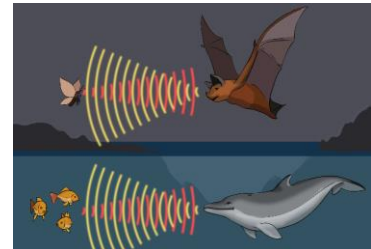
Why are the walls covered with a layer of sound-absorbing materials in recording studios?



**5. Infrasound and ultrasound**

**Infrasound waves are sound waves with a frequency of less than 20 Hz.**

Infrasound waves occur during the operation of some mechanisms, in the event of explosions, landslides, powerful gusts of wind, during a storm, or earthquake.



Infrasound is very dangerous for animals and humans: it can cause symptoms of motion sickness, dizziness, blindness, cause increased aggressiveness. In the case of prolonged exposure, intense infrasound radiation can lead to cardiac arrest.

**Ultrasonic waves are sound waves whose frequency exceeds 20 kHz.**

Ultrasound is present in the noise of wind and waterfall, in the sounds that some living things make.

How do bats and dolphins find prey in complete darkness? (Bats and dolphins emit ultrasound and perceive its echoes, so they can find their way or catch prey even in complete darkness.)

**Echolocation is a method of detecting and obtaining information about an object using echo.**

In medicine, echolocation allows you to "see" an unborn baby, examine the state of internal organs, and identify foreign bodies in tissues.

In the technique, echolocation is used to detect defects in products and measure the depths of the seas and oceans.

**6. The basic properties of waves**

**Wave properties**

1. Waves propagate in a medium at a finite speed.
2. The oscillation frequency of each part of the medium is equal to the oscillation frequency of the wave source.
3. Mechanical waves cannot propagate in a vacuum.
4. Wave movement is not accompanied by the transfer of matter.
5. During wave propagation, energy is transferred.

**7. Physical quantities that characterize oscillations**

The amplitude of oscillations is the maximum distance by which a point deviates from the equilibrium position.

$$[A] = m$$

The oscillation period is the time of one complete oscillation.

$$T = \frac{t}{N}; \quad [T] = s$$

Oscillation frequency – the number of oscillations per unit of time.

$$\nu = \frac{N}{t}; \quad [\nu] = Hz$$

**8. Wavelength**

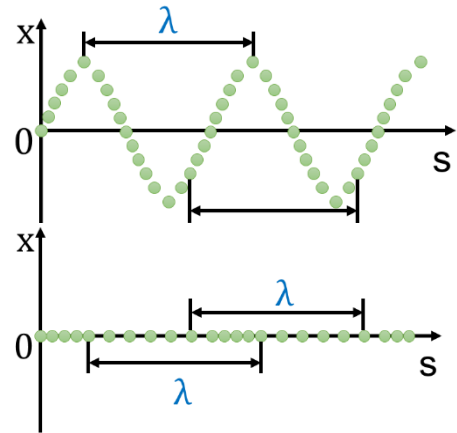
**Wavelength – the distance over which the wave propagates in a time equal to the period.**

$$\lambda = \nu T$$

$\nu$  – wave propagation velocity

$$[\lambda] = 1 m$$

**The wavelength is the distance between the wave points closest to each other, which oscillate in the same phase.**



**9. Wave propagation speed**

$$\lambda = \nu T \quad \Rightarrow \quad \nu = \frac{\lambda}{T}; \quad \frac{1}{T} = \nu; \quad \nu = \lambda \nu$$

**Wave formula:**

$$\nu = \lambda \nu$$

$\nu$  – wave propagation velocity

$\lambda$  – wavelength

$\nu$  – wave frequency

**If a wave moves from one medium to another:**

- the speed of its propagation varies.
- the frequency of the wave remains unchanged (determined by the source of the wave)
- wavelength varies

**Action**

**Part 1**

Tell the children some of the information above about waves and their parameters.

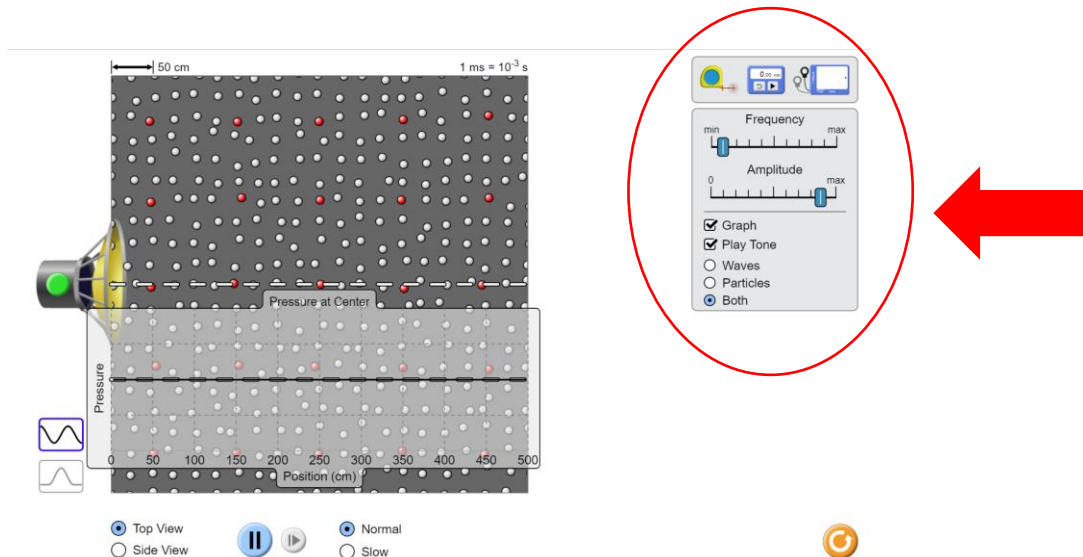
**Introduction to «Waves»**

1. Ask students to go to the website and open the 'sound' part:

[https://phet.colorado.edu/sims/html/waves-intro/latest/waves-intro\\_all.html](https://phet.colorado.edu/sims/html/waves-intro/latest/waves-intro_all.html)



2. Ask them to configure all things, like in the image below and press the green button:



3. Ask the students what they observe.

Possible answers:

- The speaker makes the molecules move.
  - The amplitude decays as a function of distance.
  - Molecules move, but their motion is more like oscillations.
  - There is a movement of energy, not matter.
4. Ask them to change different settings and say what the change affected.

Answers:

**Frequency:** more white and black lines, which means that the number of waves increases as the frequency increases

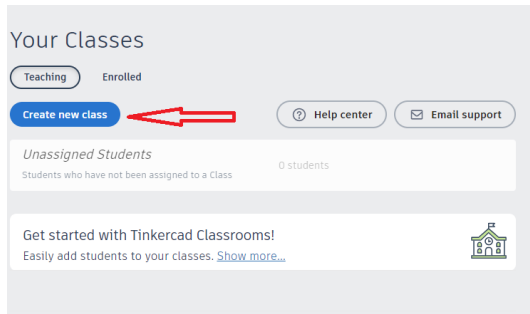
**Amplitude:** the contrast decreases, approaching gray, which means that the difference between the wave maximum and the minimum decreases

5. Ask the students what ways they know how to measure distance without using a ruler.
6. Remind students that bats and dolphins emit ultrasound and perceive its echoes, so they can find their way or catch prey even in complete darkness.
7. Tell the students that today they will be able to build and program a device that can measure distance using the property of reflection of waves.

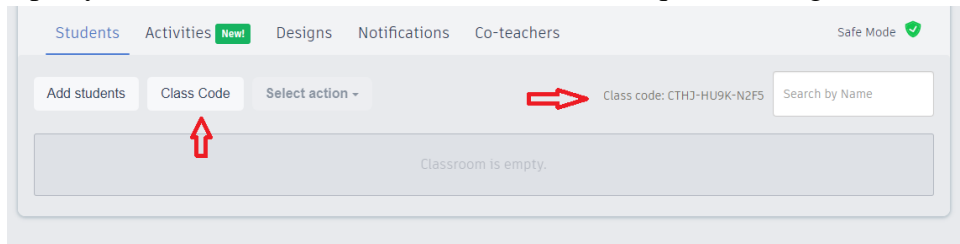
## Part 2

### Preparation

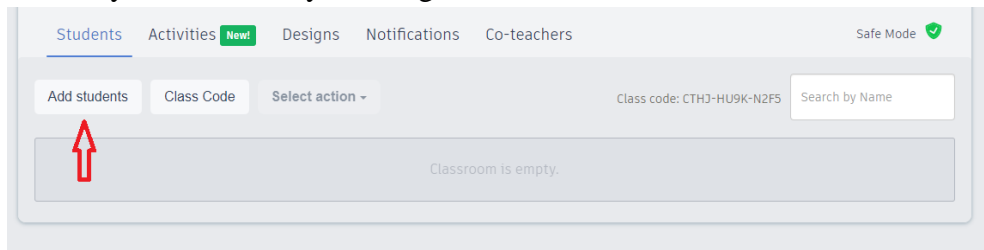
1. Sign Up like Educator on <https://www.tinkercad.com/>
2. Create a new class, give a name, choose a grade, and choose a subject:



3. Open your class and write the class code for subsequent sharing with students.



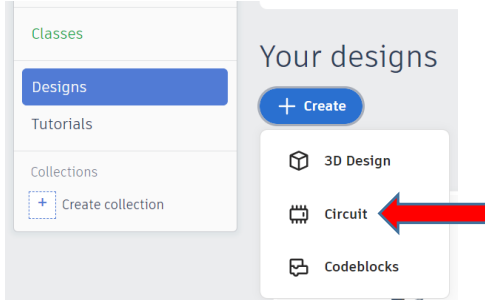
4. Add all your students by entering their names.



5. Save a list of nicknames on the computer or print.
6. Share the class code with students, and distribute nicknames personally (to avoid conflict situations between students)

**Creation of an electronic circuit of the device**

1. Ask the students to go to the site using the link and the information you have given them: <https://www.tinkercad.com/circuits>
2. Let them choose "Circuits" in the "Designs" section



3. Then **use the presentation** to build and program the device step-by-step.

**Design and assembly of the device**

If you have the appropriate electrical components, use and program them as was done in the emulator earlier.

**Consolidation/Extension**

1. Add the green colour light to the circuit and program its operation
2. If you have assembled a real device, try to test its operation on different surfaces (soft, hard, corner of a table or wall). (Answer: in the case of a soft surface and surface corners, the distance will be maximum or overestimated)
3. Talk about the topic where similar devices are used and how else you can use a similar device for what purposes

**Accommodations/Modifications**

1. You can conduct two lessons: one is theoretical, and the other is a lesson on circuit design and programming
2. You can ask students to make a three-dimensional device from cardboard, colour it, embed the development from this lesson in it and ask them to present
3. You can always use only one element of this lesson
4. In the first step, you can consider other parameters of waves, as well as waves of a different nature

**Assessment**

Not applicable. Or you can evaluate each item of the task with conditional points.

### **Additional Resources**

Wave Interference: <https://phet.colorado.edu/en/simulations/wave-interference>

Wave on a String: <https://phet.colorado.edu/en/simulations/wave-on-a-string>