Look at the picture below. With the person next to you, discuss what this might be.
SECTION 1: THE NATURE OF WAVES

A. Wave – a repeating disturbance or movement that transfers **energy** through matter or space.

1. Molecules pass energy on to **neighboring** molecules.
2. Waves carry energy without transporting **matter**.
3. All waves are produced by something that **vibrates**.
4. Medium – a **material** through which a wave travels.
   a. May be solid, liquid, or **gas**.
   b. Not all waves need a medium to travel through.

Example: **Light waves**
Falling pebbles transfer their kinetic energy to the particles of water in the pond, forming waves.

Where else have you seen waves?
A wave will exist only as long as it has energy to carry.

What happened to the energy that was carried by the wave in this rope?
B. Mechanical waves – waves that can travel only through matter.

1. Transverse waves – matter in the medium moves back & forth at right angles to the direction that the wave travels. Example: Water waves

2. Compressional waves – matter in the medium moves in the same direction that the wave travels. Example: Sound waves

3. Combinations – not purely transverse or compressional; water waves, seismic waves.
When a wave passes, the surface of the water doesn’t just move up and down.

A. The low point of a water wave is formed when water is pushed aside and up to the high point of the wave.

B. The water that is pushed aside returns to its initial position.
Forces in the Earth’s crust can cause regions of the crust to shift, bend, or even break. The breaking crust vibrates, creating seismic waves that carry energy outward, as shown in the picture below. Seismic waves are combination of compressional and transverse waves. They can travel through Earth and along Earth’s surface. When objects on Earth’s surface absorb some of the energy carried by seismic waves, they move and shake. The more the crust moves during an earthquake, the more energy is released.
How are sounds made?
SECTION 2: WAVE PROPERTIES

A. Ways waves differ

1. How much **energy** they carry
2. How **fast** they travel
3. How they look
   a. **Transverse** waves have *crests* – the highest points, and *troughs* – the lowest points.
   b. Compressional waves have dense regions called **compressions** and less dense regions called **rarefactions**.
B. Wavelength – the distance between one point in the wave and the nearest point just like it.

A. For transverse waves, a wavelength can be measured from crest to crest or trough to trough.

B. The wavelength of a compressional water wave can be measured from the start of one compression to the start of the next or the start of one rarefaction to the start of the next.
C. Frequency – how many wavelength pass a fixed point each second
   1. Expressed in hertz (Hz)
   2. As frequency increases, wavelength decreases.
   3. The frequency of a wave equals the rate of vibration of the source that creates it.

D. Wave velocity, or $v$, describes how fast the wave moves forward.
   1. $\text{velocity} = \text{wavelength} \times \text{frequency}$, or $v = \_ \times f$
   2. Light waves travel faster than sound waves.
   3. Sound waves travel faster in liquids and solids than in gas.
   4. Light waves travel faster in gases and empty space than in liquids and solids.
1. __________ is a repeating disturbance or movement that transfers energy through matter or space.
2. Waves carry energy without transporting __________.
3. All waves are produce by something that __________.
4. A __________ is a material through which a wave travels.
5. Mediums may be a __________, __________, or _____.
6. The type of wave where the matter in the medium moves back and forth at right angles to the direction that the wave travels is a ___________ wave.
7. The type of wave where the matter in the medium moves in the same direction that the wave travels is a ___________ wave.
8. Which type of wave has crests and troughs?
9. Which type of wave has compressions and rarefactions?
10. The distance between one point in a wave and the nearest point just like it is called a ________________.
The wavelength of a wave decreases as the frequency increases.

A. The rope is moved down, up and down again one time is 1 s. One wavelength is created on the rope.

B. The rope is shaken down, up, and down again twice in 1 s. Two wavelengths are created on the Rope.
Calculating wave velocity

1. A wave is traveling at a velocity of 12 m/s and its wavelength is 3 m. Calculate the wave frequency.

2. A wave is traveling at a speed of 18 m/s with a frequency of 3 Hz. A second wave is traveling at a speed of 16 m/s with a frequency of 4 Hz. What is the difference between these two wavelengths?
E. Amplitude – a measure of the energy in a wave.

1. The more energy a wave carries, the greater its amplitude.
2. Amplitude of compressional waves is related to how tightly the medium is pushed together at the compression.
   a. The denser the compressions, the larger the amplitude is and the more energy the wave carries.
   b. The less dense the rarefactions, the larger the amplitude and the more energy the wave carries.
3. Amplitude of transverse waves
   a. The distance from the crest or trough of a wave to the normal position of the medium.
   b. Example: how high an ocean wave appears above the water level.
In a lightning storm, why do you see the lightning before you hear the thunder?
A. Reflection occurs when a wave strikes an object and **bounces off** of it

1. **All** types of waves can be reflected.

2. The angle of incidence of a wave is always equal to the angle of reflection.
   a. Normal – an imaginary line **perpendicular** to a reflective surface
   b. Angle of **incidence** – the angle formed by the wave striking the surface and the normal.
   c. Angle of **reflection** – the angle formed by the reflected wave and the normal
B. Refraction – the **bending** of a wave caused by a change in its speed as it moves from one medium to another.

1. The greater the change in speed is, the **more** the wave bends.
2. When a wave passes into a material that slows it down, the wave is bent **toward** the normal.

3. When a wave passes into a material that speeds it up, the wave is bent **away from** the normal.
To the observer on the side of the pool, the swimmer’s foot looks closer to the surface than it actually is.

*When the boy looks down at his feet, will they seem closer to the surface than they really are?*
C. Diffraction – an object causes a wave to change direction and *bend* around it

1. If the obstacle is *smaller* than the wavelength, the wave diffracts a lot.

2. If the obstacle is much *larger* than the wavelength the wave does not diffract much.

3. The larger the obstacle is compared to the wavelength, the *less* the waves will diffract.
The diffraction of wave around an obstacle depends on the wavelength and the size of the obstacle.

A. Less diffraction occurs if the wavelength is smaller than the obstacle. A. More diffraction occurs if the wavelength is the same size as the obstacle.
D. Interference – the ability of two or more waves to **combine** and form a new wave

1. Waves pass right through each other and continue in **their original direction**.
2. New wave exists only while the two original waves continue to **overlap**.

A. Two waves move toward each other on a rope.

B. As the waves overlap, they interfere to form a new wave.

C. When the two waves meet they move right through each other, and continue moving unchanged, as if they had never met.
3. Constructive interference – waves **add** together.

4. Destructive interference – waves **subtract** from each other
E. Standing waves – a wave pattern that stays in **one place**.
1. Form when waves of equal **wavelength** and amplitude that are traveling in **opposite** directions continuously interfere with each other.
2. Nodes – the places where two waves **always** cancel each other.

F. Resonance – the ability of an object to **vibrate** by absorbing energy at its natural frequency