Wave Behavior @ Boundaries

Wave Behavior @ Boundaries

- We know that waves travel through mediums.
- But what happens when that medium runs out?

- The behavior of a wave when it reaches the end of its medium is called the wave's BOUNDARY BEHAVIOR.
- When one medium ends and another begins, that is called a boundary.

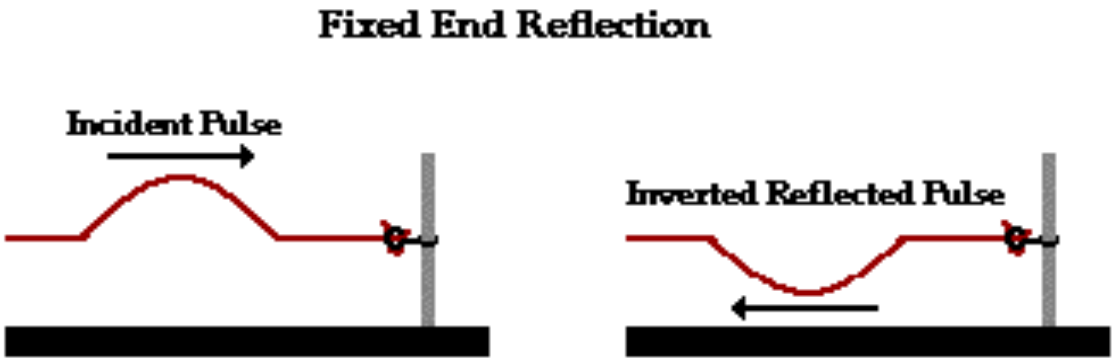
Fixed End

- One type of boundary that a wave may encounter is that it may be attached to a fixed end.
- In this case, the end of the medium will not be able to move.
- What is going to happen if a wave pulse goes down this string and encounters the fixed end?

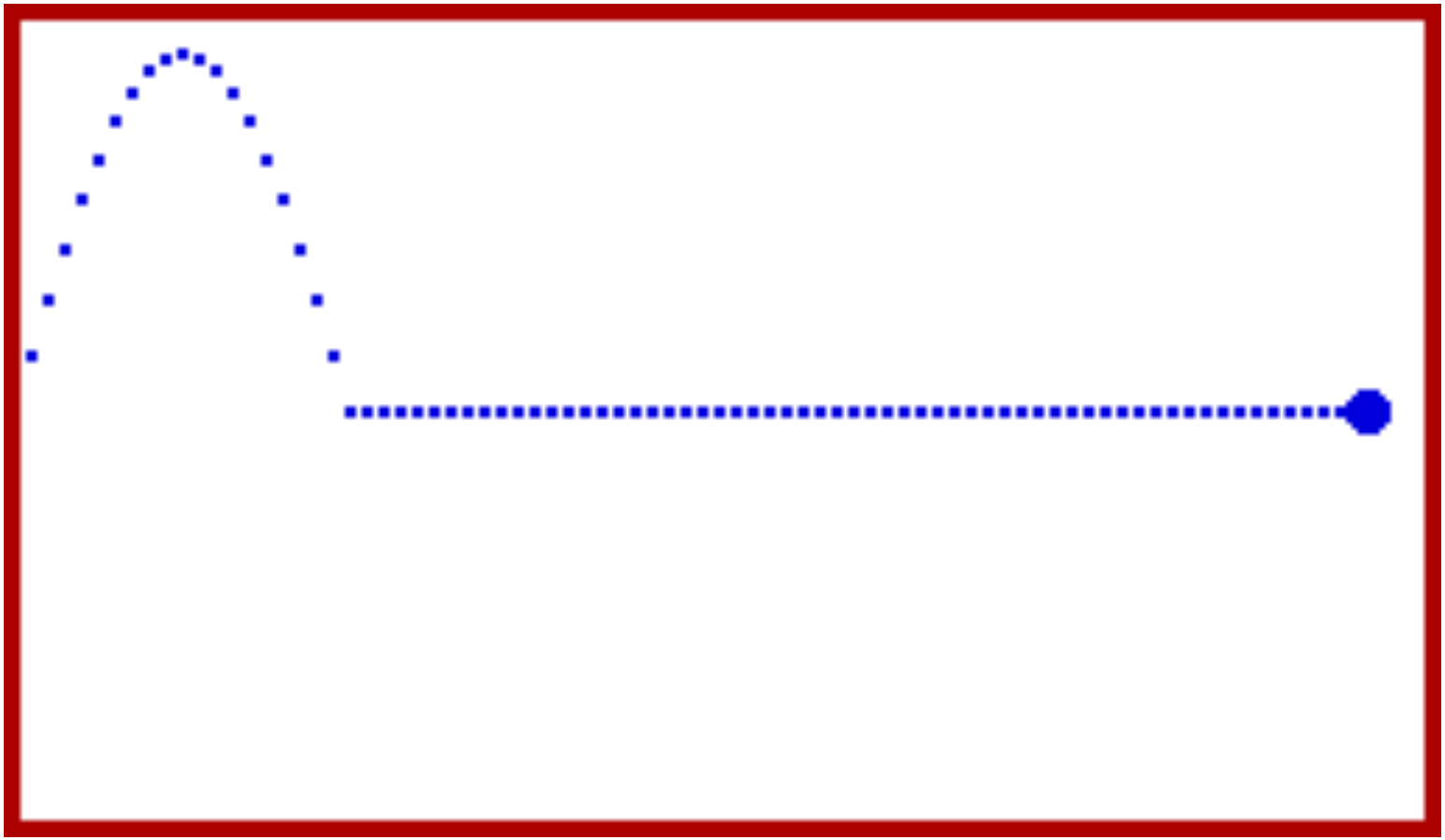
An elastic rope securely tied to a pole can be used to study the behavior of waves at a fixed end.

Fixed End

- Here the incident pulse is an upward pulse.
- The reflected pulse is upside-down. It is inverted.
- The reflected pulse has the same speed, wavelength, and amplitude as the incident pulse.



Fixed End Animation



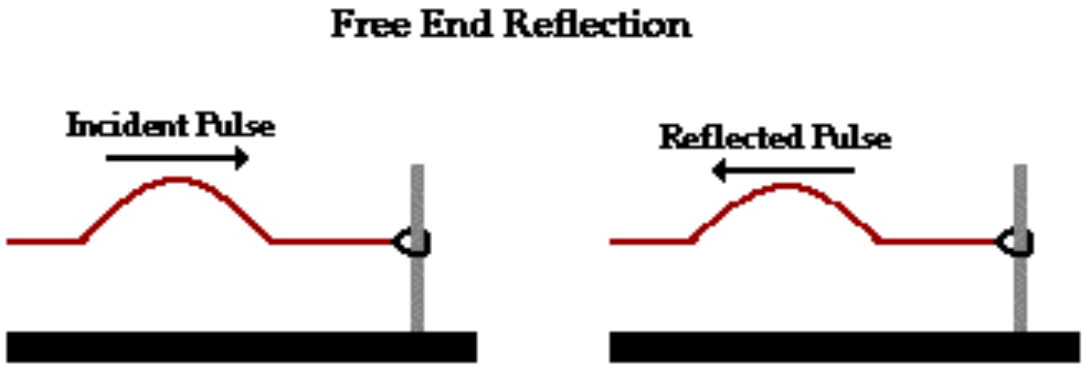
Free End

- Another boundary type is when a wave's medium is attached to a stationary object as a free end.
- In this situation, the end of the medium is allowed to slide up and down.
- What would happen in this case?

If the end of an elastic rope not fastened to the pole then it will be free to move up and down. This provides for the study of wave behavior at free ends.

Free End

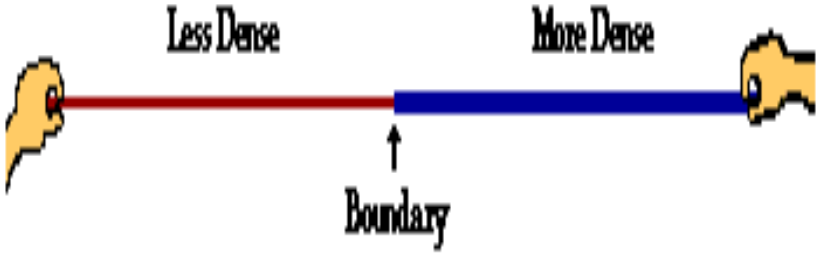
- Here the reflected pulse is not inverted.
- It is identical to the incident pulse, except it is moving in the opposite direction.
- The speed, wavelength, and amplitude are the same as the incident pulse.



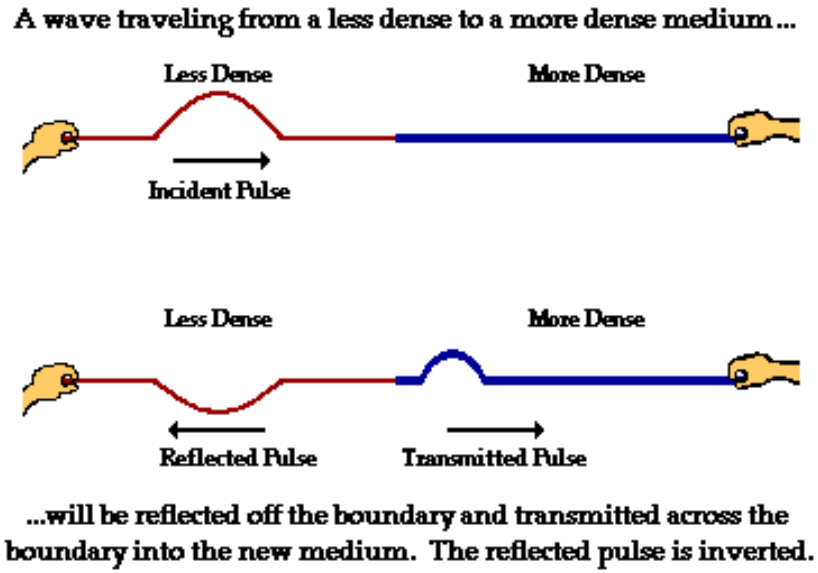
Free End Animation

Change in Medium

- Our third boundary condition is when the medium of a wave changes.
- Think of a thin rope attached to a thin rope. The point where the two ropes are attached is the boundary.
- At this point, a wave pulse will transfer from one medium to another.
- What will happen here?

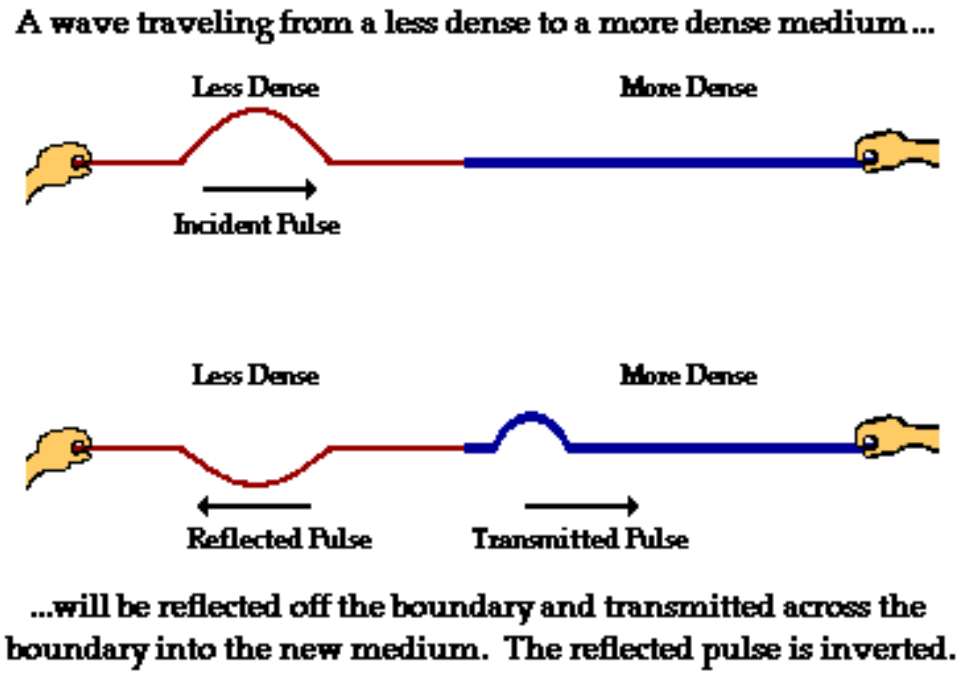


Change in Medium



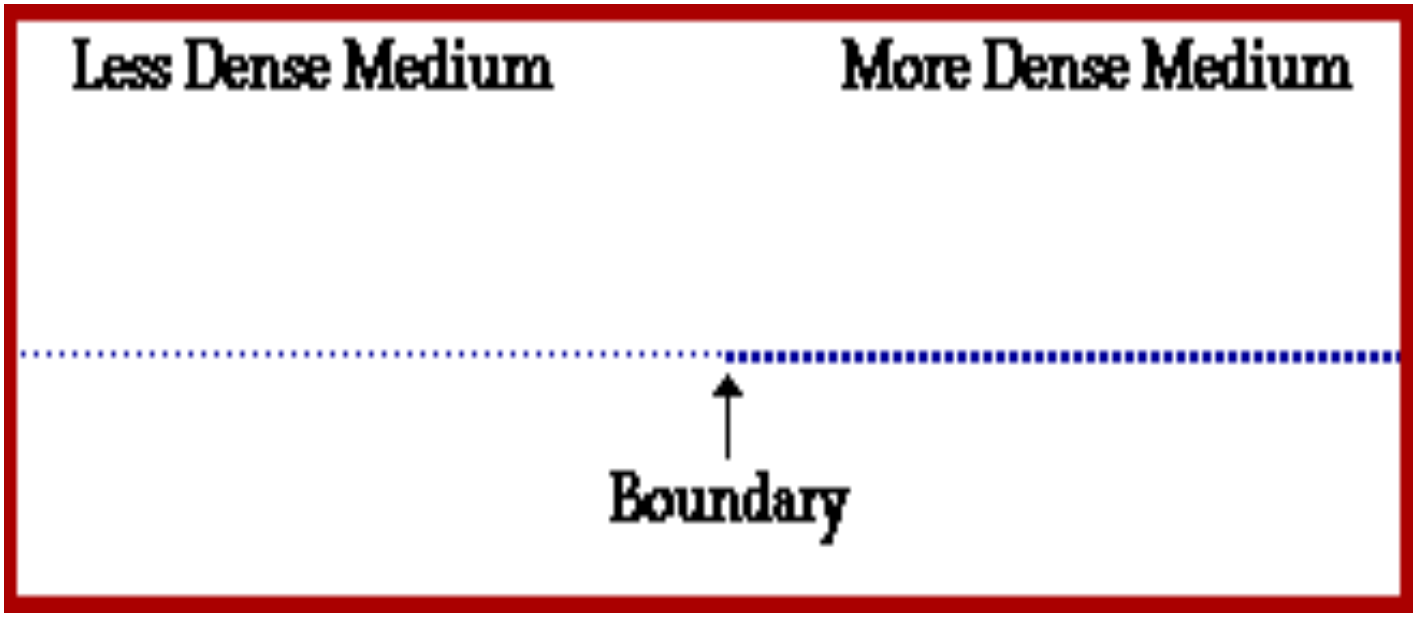
- In this situation part of the wave is reflected, and part of the wave is transmitted.
- Part of the wave energy is transferred to the more dense medium, and part is reflected.
- The transmitted pulse is upright, while the reflected pulse is inverted.

Change in Medium



- The speed and wavelength of the reflected wave remain the same, but the amplitude decreases.
- The speed, wavelength, and amplitude of the transmitted pulse are all smaller than in the incident pulse.

Change in Medium Animation



Changing Wave Direction

- We have learned that waves behave in unique ways when they reach boundaries of different mediums.
- When those waves are not constrained to move in one direction (such as in a rope or slinky), they may also change their direction. This change in direction can have different causes:

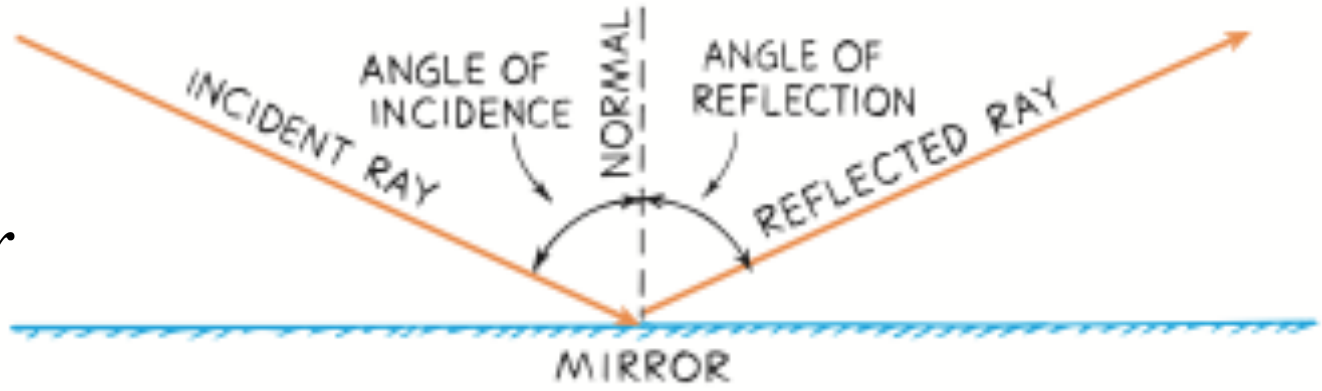
1. **Reflection**
2. **Refraction**
3. **Diffraction**

Changing Wave Direction - 1

1. **Reflection:** When waves bounce off a surface.

- If the surface is flat, the angle at which the wave hits the surface will be the same as the angle at which it leaves the surface

$$\theta_i = \theta_r$$

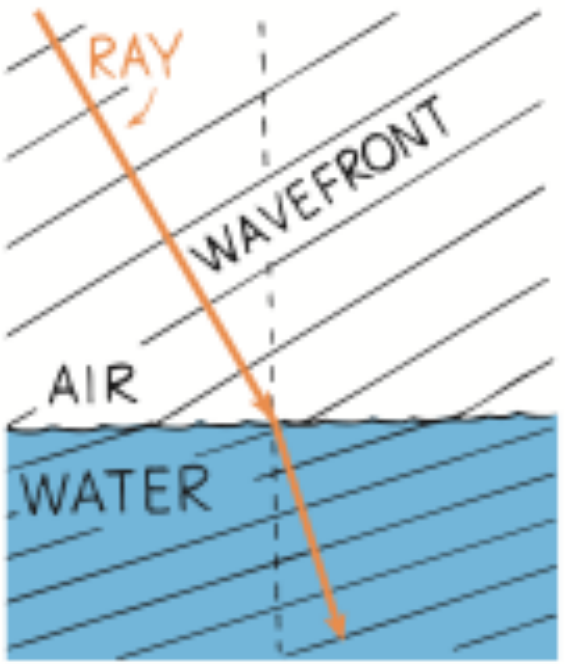


Law of Reflection – the angle of incidence and the angle of reflection are equal

Changing Wave Direction - 2

2. **Refraction:** Waves can bend.

- This happens when a wave enters a new medium and its SPEED CHANGES.
- The amount of bending depends on the medium it is entering.
- When waves enter a different medium, their FREQUENCY always stays the same.



Changing Wave Direction - 3

3. **Diffraction:** The bending of waves AROUND an object.

- The amount of bending depends on the size of the obstacle and the size of the waves.