Waves

So, what does a parade and this lesson plan have in common? A lot of waves! People wave in a parade and this lesson is about waves. Get it? Oh well, that's why I'm a science teacher and not a stand-up comic. Anyway, last lesson we talked about vibrations and frequency. This lesson we are going to look more carefully at what those vibrations make, and that's waves.

Waves are the way energy moves from place to place. Sound moves from a mouth to an ear by waves. Light moves from a light bulb to a book page to your eyes by waves. Waves are everywhere. As you sit there reading this, you are surrounded by radio waves, television waves, cell phone waves, light waves, sound waves and more. (If you happen to be reading this in a boat or a bathtub, you're surrounded by water waves as well.) There are waves everywhere! Do you remember where all waves come from? Vibrating particles. Waves come from vibrating particles and are made up of vibrating particles.

Here's rule one when it comes to waves....the waves move, the particles don't. The wave moves from place to place. The wave carries the energy from place to place. The particles however, stay put. Here's a couple of examples to keep in mind. If you've ever seen a crowd of people do the "wave" in the stands of a sporting event you may have noticed that the people only "vibrated" up and down. They did not move along the wave. The wave, however, moved through the stands. Another example, would be a duck floating on a wavy lake. The duck is moving up and down (vibrating) just like the water particles but he is not moving with the waves. The waves move but the particles don't. When I talk to you, the vibrating air molecules that made the sound in my mouth do not travel across the room into your ears. (Which is especially handy if I've just eaten an onion sandwich!) The energy from my mouth is moved, by waves, across the room. Waves are energy-mobiles.

Why are waves energy-mobiles? Remember that energy is the ability to do work, and work is moving something a distance against a force. Can you tell me what is moving against a force in a wave? If you said particles you're right. Water particles, molecules, electrons, some sort of small particles are moving back and forth at potentially incredible speeds against a force. Each particle moving does work on another particle which gets it moving. That

particle then does work on another particle which gets it moving, which then does work on another particle getting it moving, which then gets another moving and so on and so forth. Particles moving and doing work on other particles is energy and waves are how energy moves.

Transverse and Longitudinal Waves

Physics is really nice to us here because, believe or not, with all the different forms of energy there are only two types of waves to remember; transverse and longitudinal. Neat, huh? That makes it pretty easy. So let's talk about them. **A transverse wave is a wave where the particle moves perpendicular to the medium. A longitudinal wave is where the particle moves parallel to the medium.** "Ummm....so much for easy". Hold on a minute, let me explain and make that a little simpler. Better yet, let's just see it.

Experiment 1
The Up's and Down's of Waves

You need:
A rope (at least 10 feet long)
A friend or something to tie the rope to (don't worry, you're not tying up your friend!)
Piece of tape (if you have colored tape, that's even better)

1. Put a piece of tape in about the middle of the rope.

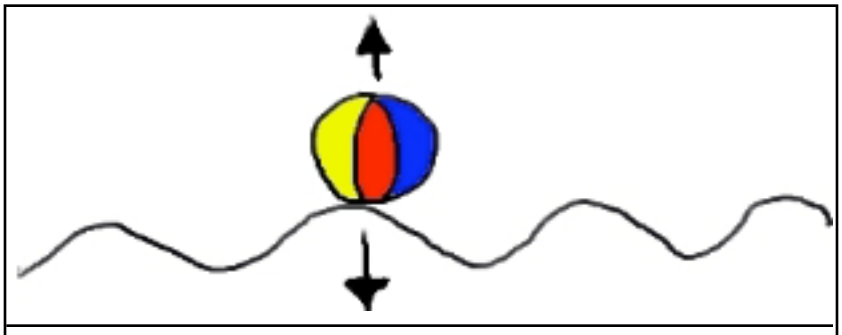
2. Tie your rope to something or let your friend hold on to one end of it.

3. Now pull the rope so that it is a bit slack but not quite touching the floor.

4. Vibrate your arm. Move your arm up and down once and watch what happens.

5. Now, vibrate your arm a bunch of times (not too fast) and see the results. Notice the action of the tape in the middle of the rope.

What you've done is create a transverse wave. With a transverse wave, if the particle (in this case your hand) moves up and down, the wave will move to the left and/or right of the particle. The word perpendicular means that if one thing is up and down, the other thing is left and right. **A transverse wave is a wave where the particle moves perpendicular to the medium.** The medium is the material that's in the wave. The medium in this case is the rope. For example, in a water wave, the medium is the water. Your hand moved up and down, but the wave created by your hand moved across the room, not up. The wave moved perpendicular to the motion of your hand.



The beach ball is just like the particles. It vibrates up and down as the wave moves left or right. The ball is moving perpendicular to the wave.

Did you take a look at the tape? The tape represents a particle in the wave. Notice that it too, was going up and down. It was not moving along the wave. In any wave the particles vibrate, they do not move along the wave.

Now that you've seen a transverse wave, let's take a look at a longitudinal wave.

Experiment 2
The Back and Forth of Waves

You need:

A slinky
A friend or some way to anchor one end of the slinky down
A smooth floor
Tape (again, colored tape would be better)

1. Put a piece of tape on one slinky wire in the middle or so of the slinky.

2. Let your friend hold on to one end of the slinky or anchor the slinky to a chair or table.

3. Now stretch the slinky out, but not too far.

4. Quickly push the slinky toward your friend, or the table, and then pull it back to its original position. Did you see the wave?

5. Now do it again, back and forth several times and watch where the slinky is bunched up and where it's spread out.

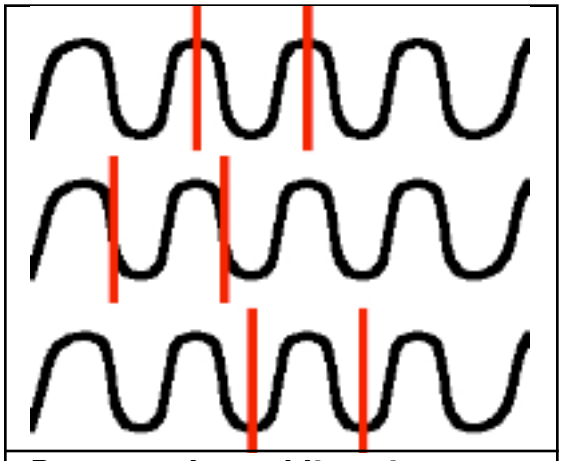
6. Notice the tape. What is it doing?

Here you made a longitudinal wave. **A longitudinal wave is where the particle moves parallel to the medium.** In other words, your hand vibrated in the same direction (parallel to the direction) the wave was moving in. Your vibrating hand created a wave that was moving in the same direction as the hand was moving in. Did you take a look at the tape? The tape was moving back and forth in the same direction the wave was going. Do you see the difference between a transverse wave and a longitudinal wave? In a transverse waves the particles vibrate in a different direction (perpendicular) to the wave. In a longitudinal wave the particles vibrate in the same direction (parallel) to the wave.

In this case the beach ball is moving back and forth in the same direction as the wave.

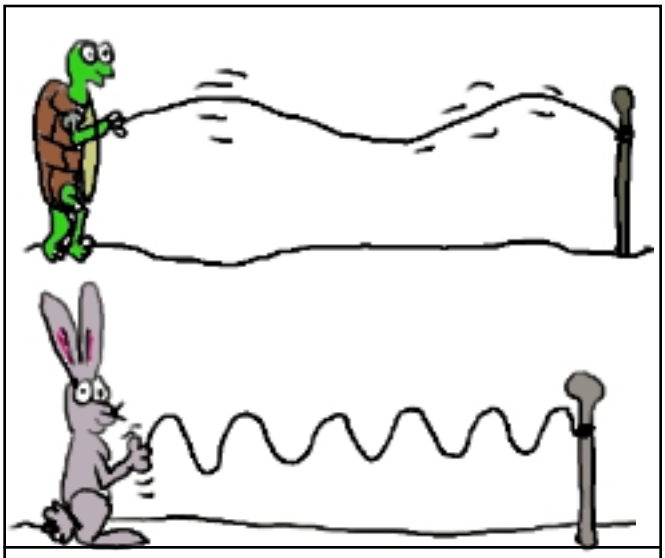
I'm going to throw a few definitions at you here so hold on. After we get through this, we'll play with them. A wave has several aspects to it that are important to notice and be able to talk about.

Wavelength



Between the red lines is one wavelength. Notice that for each of the above waves the wavelength is the same.

Wavelength is the first definition I want to give you here. **The wavelength is the distance between two like parts of the wave.** In other words, the wavelength is the distance between two high parts (hills) of the wave. Or it's the distance between two low parts (troughs) of the wave. Take a look at the picture to make this clearer. Wavelength is related to the frequency of the wave. The faster the frequency (the faster the vibrating particle) the smaller the wavelength. When it comes to sound waves, wavelength determines the pitch of the sound. "Hey Jim…last lesson you said frequency determined the pitch of sound!" Very good, you're paying great attention! Yes that is true, frequency does determine the pitch of sound and is the normal way we would describe that sound. The sound has a frequency of 200 Hz for example. However, frequency determines the wavelength of a sound so frequency and wavelength are two different ways of talking about the pitch of the sound. When it comes to electromagnetic waves the wavelength (just like the frequency again) determines whether the

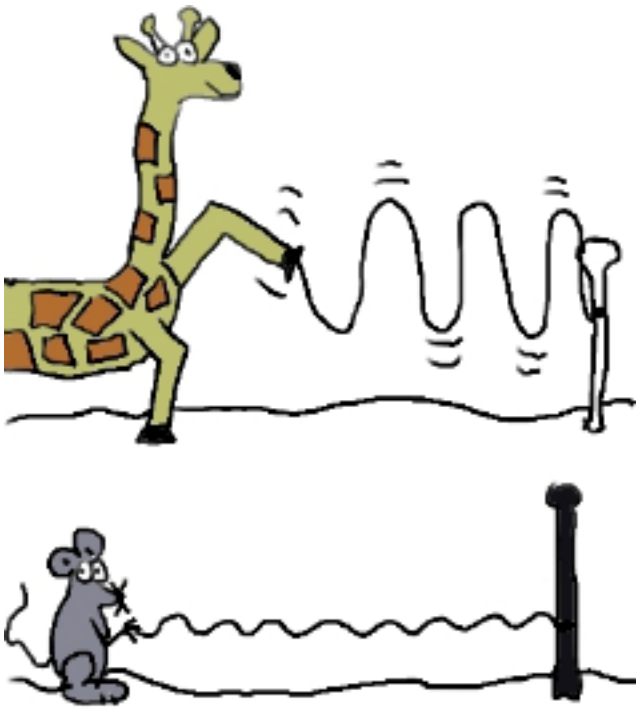


Notice how Tommy Turtle, with his slow frequency, is making large wavelengths. Whereas Ron Rabbit, with his fast frequency, is making small wavelengths.

wave is radio or microwave or light, ect.

Amplitude

Amplitude is the height of the wave. The higher the amplitude, the higher the wave. Also, the higher the amplitude the higher the energy of the wave. Can you see why? If the wave has a high amplitude, how must the particles in the wave be moving? A lot, or a little? If you said a lot you're right! For a wave to have a high amplitude the particle has to be moving over a large distance (large being a relative term here, the distance may still be miniscule). The more the particle moves, the more work there is being done on the particle (work is force and distance). The more work there is, the more energy there is and so, a wave with a large amplitude has more energy then a wave with a small amplitude. If you've ever been in the ocean this may be more clear. Small little waves don't have the energy to knock you over, but the larger ones...watch out! In sound, amplitude determines the loudness of the sound. In light, amplitude determines the brightness.



The wave of Gerry Giraffe has a much larger amplitude than the wave of Marla Mouse which has a small amplitude.

Experiment 3
Turn Up the Amplitude

This is the same set up as Experiment 1 but we're going to pay attention to some different things here.
You need:

A rope (at least 10 feet long)
A friend
Piece of tape (if you have colored tape, that's even better)

1. **Put a piece of tape in about the middle of the rope.**

2. **Tie your rope to something or let your friend hold on to one end of it.**

3. **Now pull the rope so that it is a bit slack but not quite touching the floor.**

4. **Your friend should hold their hands as still as possible.**

5. **Vibrate your hand but only move it up and down about a foot or so. Have your partner pay attention to how that feels when the wave hits him or her.**

6. **Now, vibrate your hand but now move it up and down 2 or 3 feet. How does that feel to your partner?**

7. **Have your partner do the vibrating now and see what you feel.**

You created two different amplitude waves. The first wave had a smaller amplitude than the second wave. What you and your partner should have felt was more energy the second time. The wave should have hit your hand with more energy when the wave had more amplitude.

Experiment 4
Wavelength

You need:

Same old rope
Same old friend or same old something to tie it to.

1. **Tie your rope to something or let your friend hold on to it.**

2. **Now pull the rope so that it is a bit slack but not quite touching the floor.**

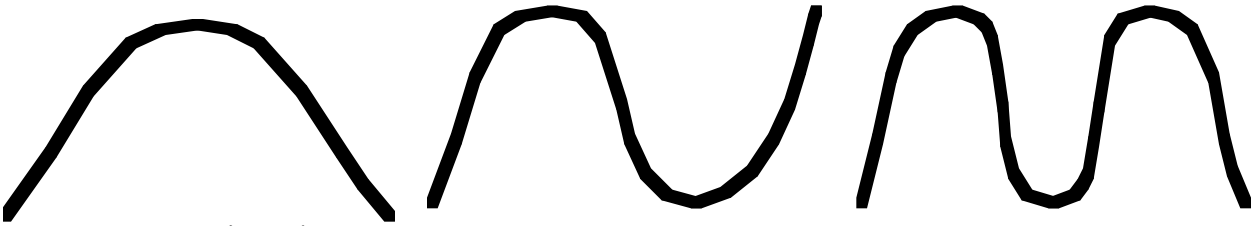
3. **Your friend should hold their hands as still as possible.**

4. **Now begin vibrating your hand fairly slowly. In this case, it works better if you move your hand in a circle.**

5. **Try to make a half wavelength with the rope. In other words it will look like you're playing jump rope.**

6. **Now try a full wavelength.**

7. **Can you get one and a half, two, or more wavelengths? You've really got to get your hand moving to get it.**



One Wavelength | One and a Half Wavelengths | Two Wavelengths

Did you notice how the frequency of your hand determined the wavelength of the rope. The faster your hand, moved the more wavelengths you could get.

In a Nutshell

Waves are the way energy moves from place to place. Waves are energy-mobiles.

Waves move. The particles in the wave only vibrate.

Particles in a wave are moving a distance against a force. They are having work done on them and they can do work.

A transverse wave is a wave where the particle moves perpendicular to the medium.

A longitudinal wave is where the particle moves parallel to the medium.

The wavelength is the distance between two like parts of the wave.

Amplitude is the height of the wave.

Did you get it?

1. How does energy move?

2. True or false: the particles in a wave move from where the wave starts to where the wave ends up.

3. What is having work done on it in a wave?

4. What are the two type of waves?

5. In which wave do the particles vibrate in the same direction as the wave?

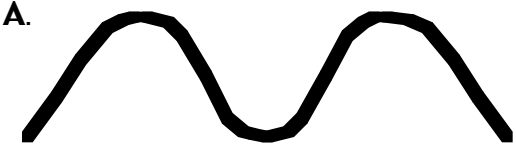
6. In which wave do the particles vibrate perpendicularly to the direction of the wave?

7. What does wavelength mean?

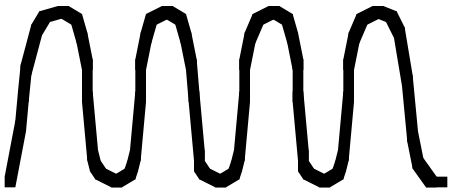
8. What does amplitude mean?

9. Which of the following has the longer wavelength?

A.

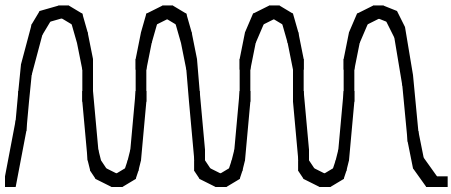


B.

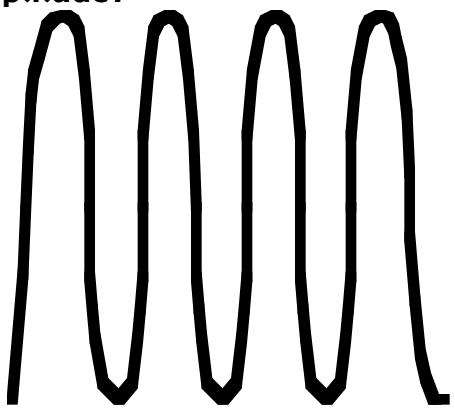


10. Which of the following has the larger amplitude?

A.



B.



Answers

1. Energy moves by waves.

2. False; particles only vibrate, they do not move along the wave.

3. Particles are being moved against a force. Work is being done on them and they are doing work on other particles.

4. Transverse and longitudinal.

5. Longitudinal.

6. Transverse.

7. Wavelength is the distance between two like parts of the wave.

8. Amplitude is the height of the wave.

9. "A" has the longer wavelength.

10. "B" has a larger amplitude.