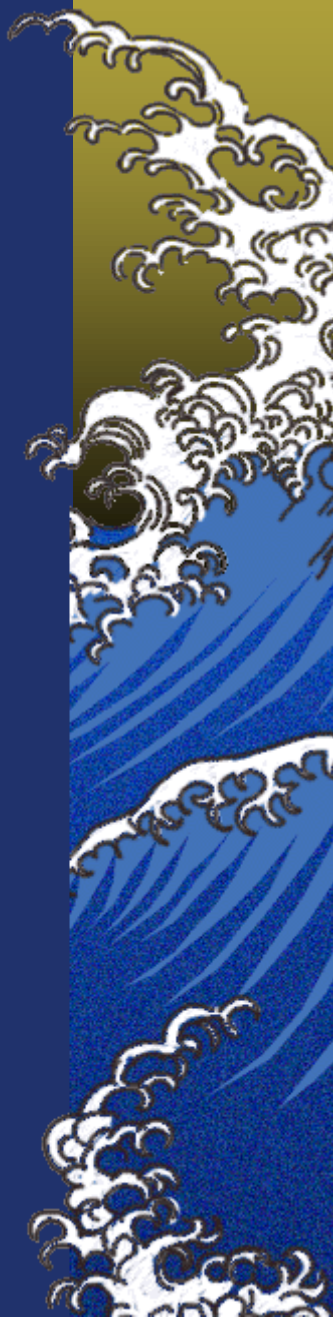
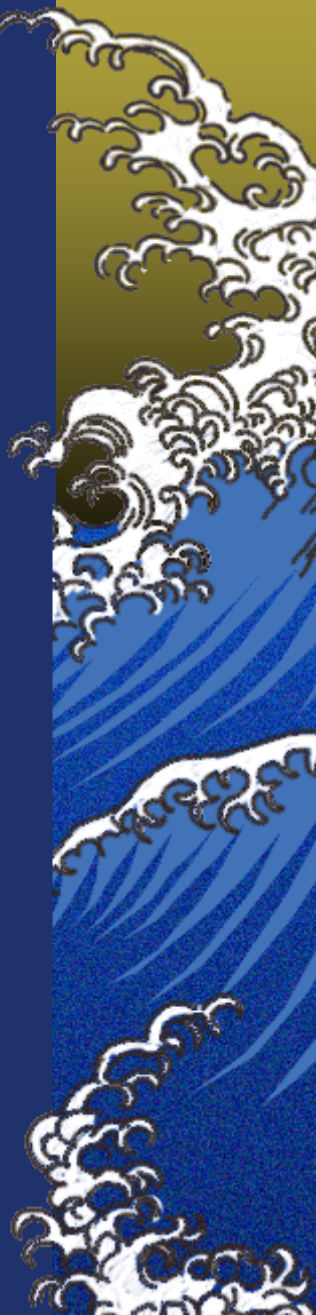
Waves and Vibrations



Waves are everywhere in nature

- *Sound waves,*
- *visible light waves,*
- *radio waves,*
- *microwaves,*
- *water waves,*
- *sine waves,*
- *telephone chord waves,*
- *stadium waves,*
- *earthquake waves,*
- *waves on a string,*
- *slinky waves*



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What is a wave?

- *a wave is a disturbance that travels through a medium from one location to another.*
- *a wave is the motion of a disturbance*

Longitudinal Wave

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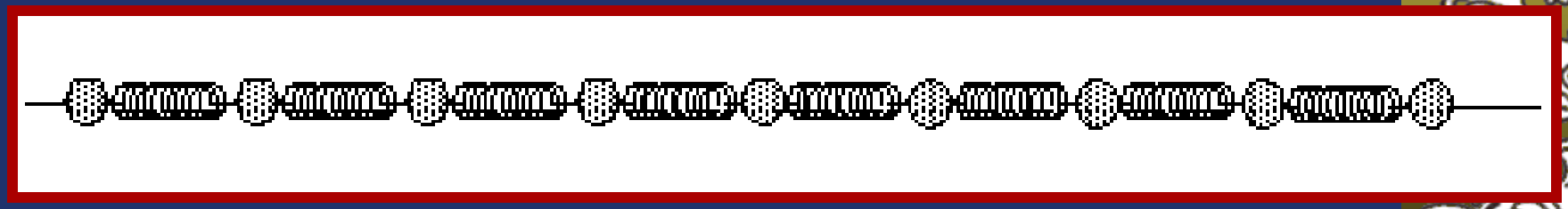


- *The wave we see here is a longitudinal wave.*
- *The medium particles vibrate parallel to the motion of the pulse.*
- *This is the same type of wave that we use to transfer sound.*
- *Can you figure out how??*

show tuning fork demo

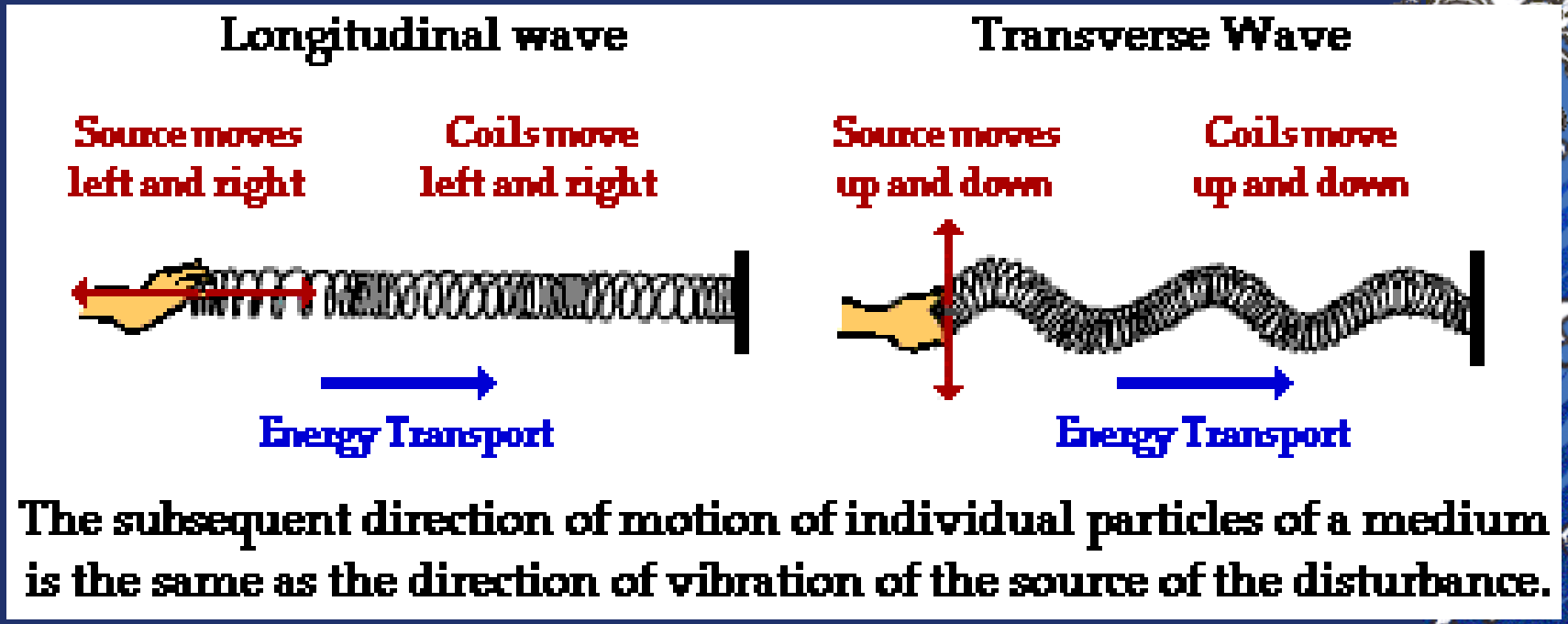
copy this

Transverse waves

- *A second type of wave is a transverse wave.*
- *We said in a longitudinal wave the pulse travels in a direction parallel to the disturbance.*
- *In a transverse wave the pulse travels perpendicular to the disturbance.*

Transverse Waves

- *The differences between the two can be*

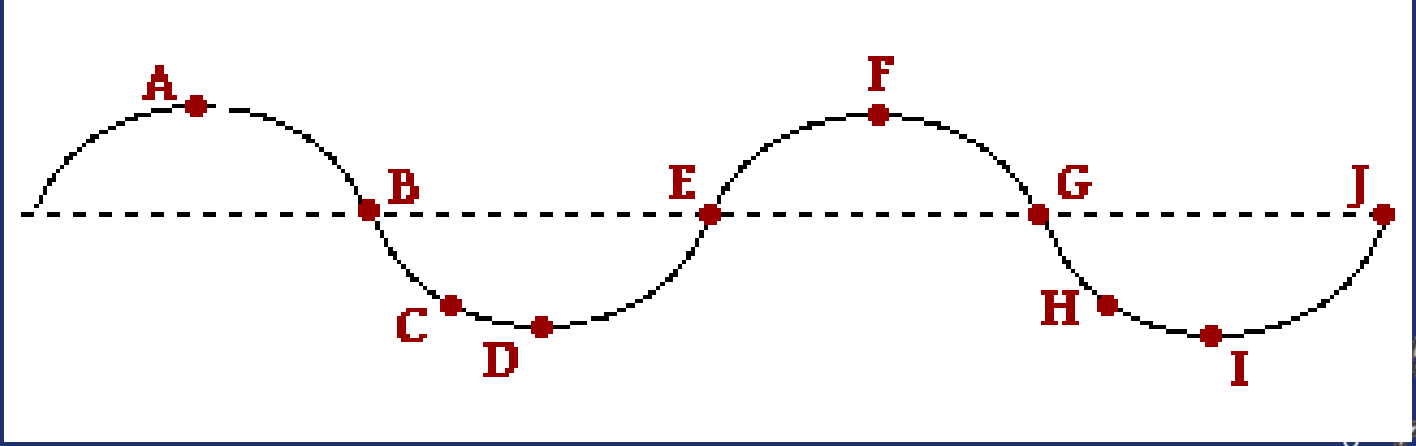


Transverse Waves

- *Transverse waves occur when we wiggle the slinky back and forth.*
- *They also occur when the source disturbance follows a periodic motion.*
- *A spring or a pendulum can accomplish this.*
- *The wave formed here is a SINE wave.*
- *http://webphysics.davidson.edu/course_material/py130/demo/illustration16_2.html*

Anatomy of a Wave

- *Now we can begin to describe the anatomy of our waves.*
- *We will use a transverse wave to describe this since it is easier to see the pieces.*



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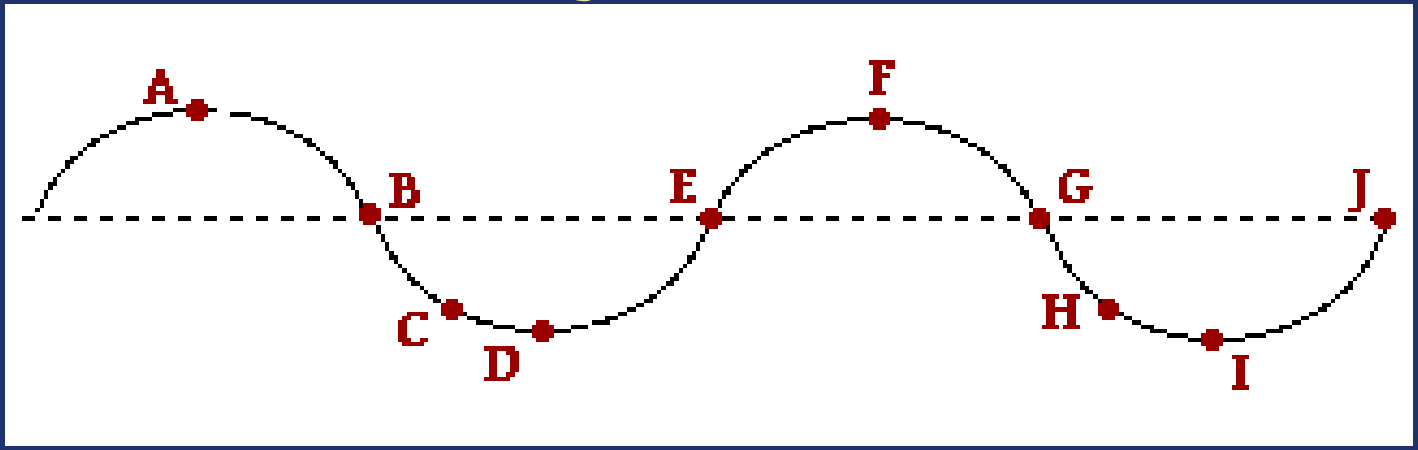
Anatomy of a Wave



- In our wave here the dashed line represents the equilibrium position.
- Once the medium is disturbed, it moves away from this position and then returns to it

Anatomy of a Wave

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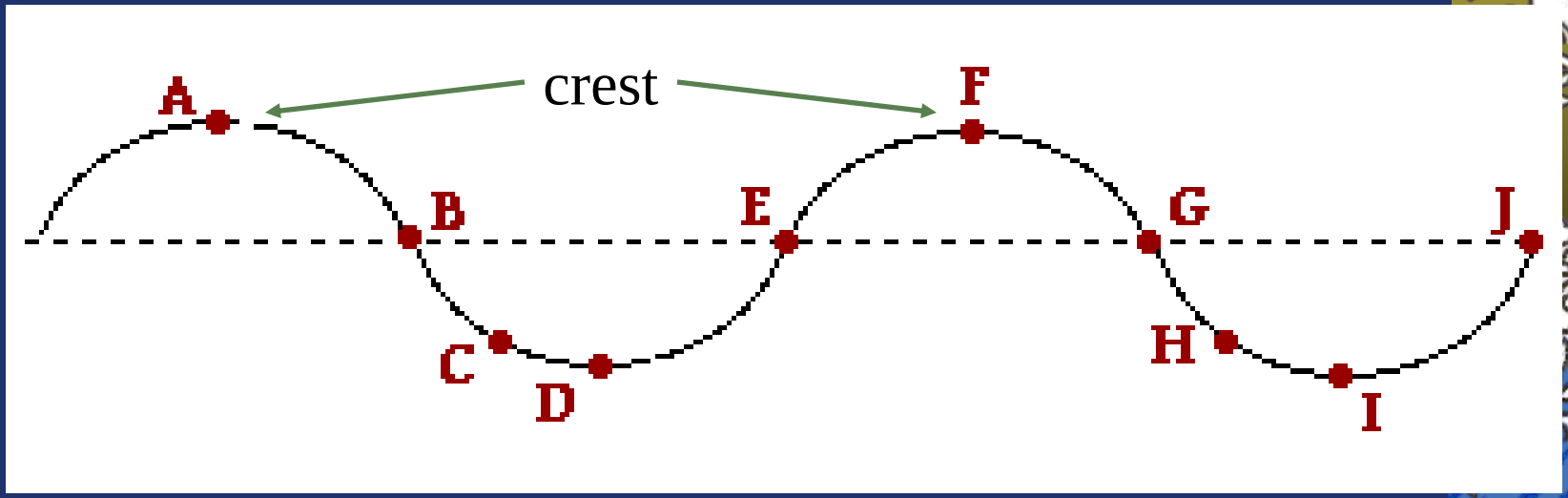

- *The points A and F are called the CRESTS of the wave.*
- *This is the point where the wave exhibits the maximum amount of positive or upwards displacement*

Anatomy of a Wave

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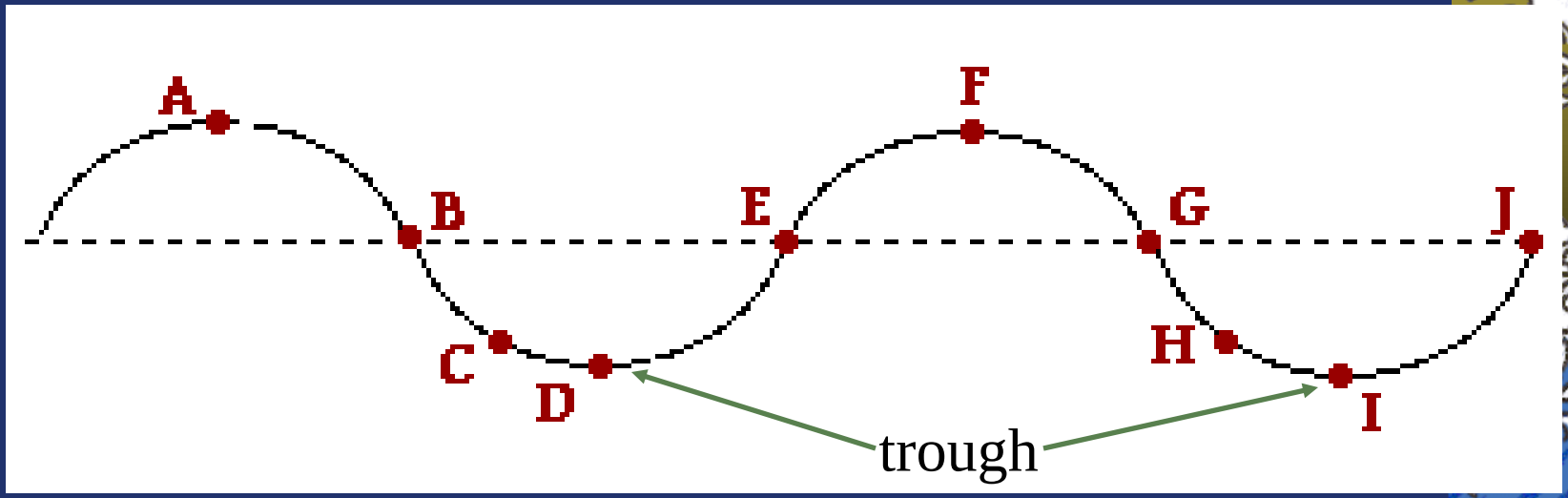

- *The points D and I are called the TROUGHS of the wave.*
- *These are the points where the wave exhibits its maximum negative or downward displacement.*

Anatomy of a Wave

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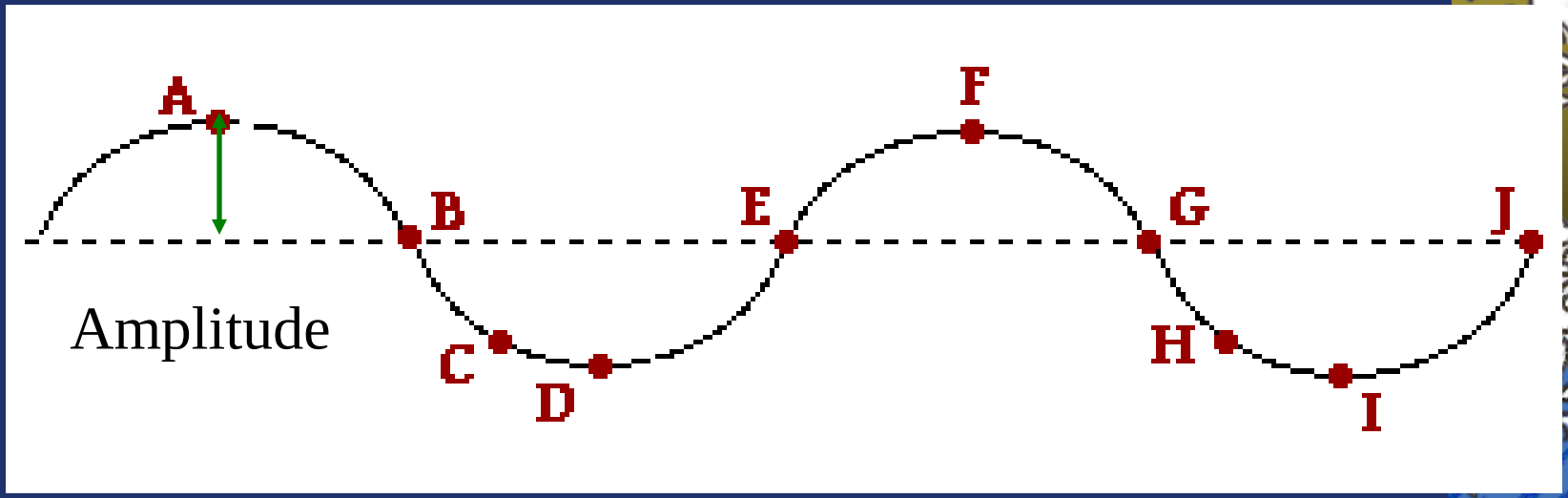

- *The distance between the dashed line and point A is called the Amplitude of the wave.*
- *This is the maximum displacement that the wave moves away from its equilibrium.*

Anatomy of a Wave

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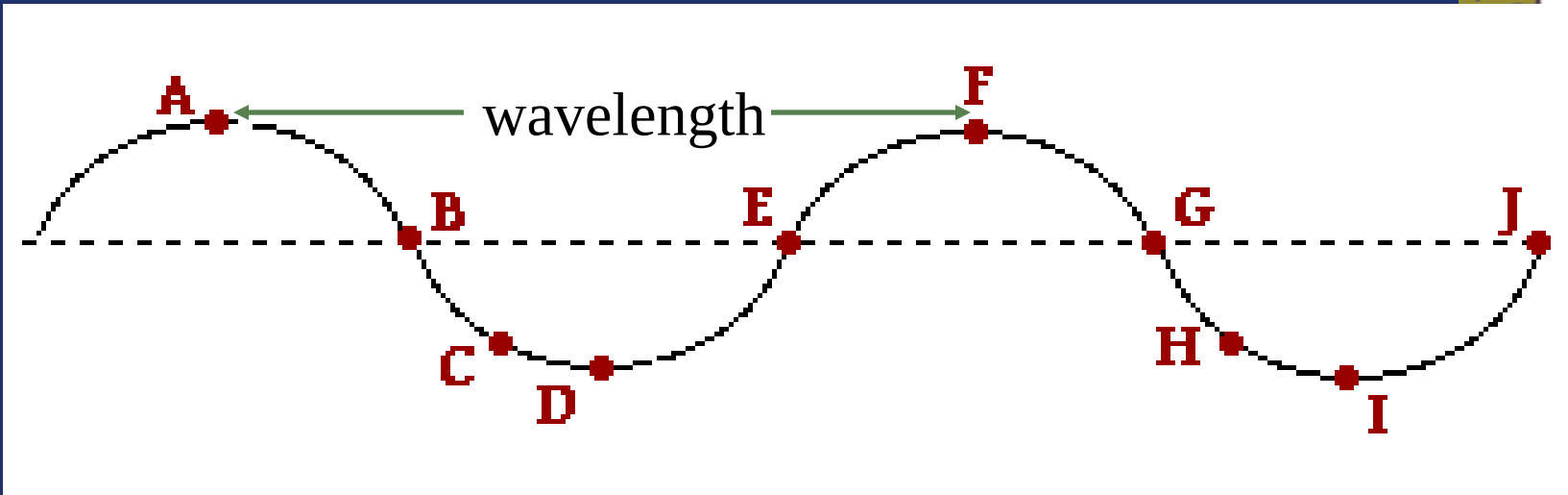
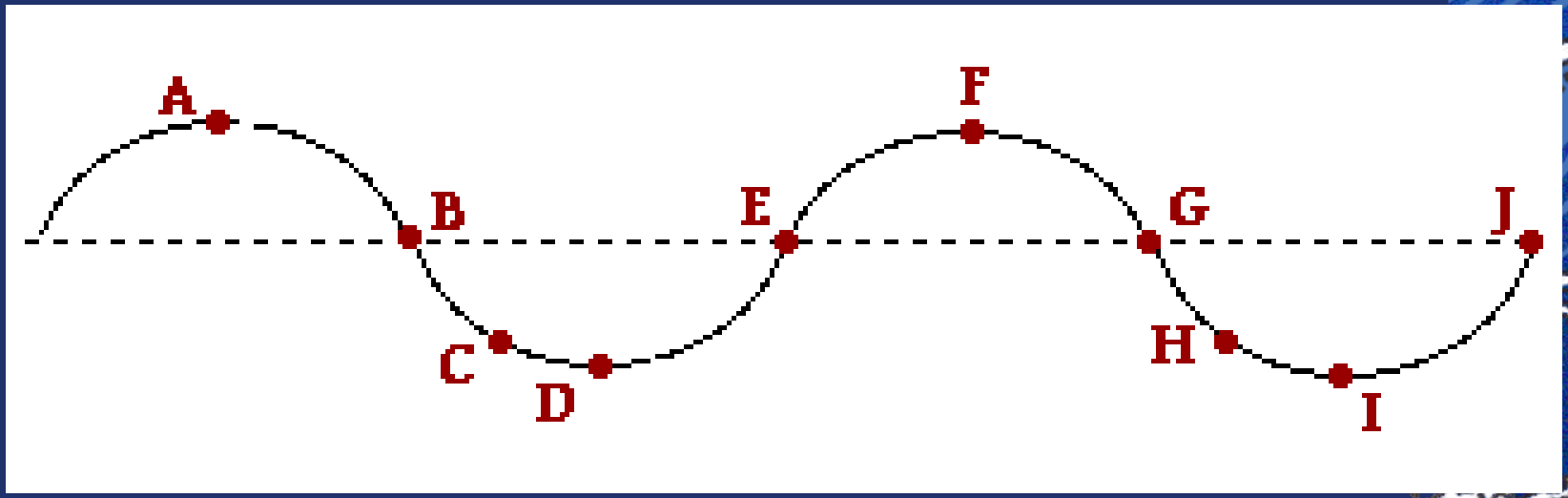


- *The distance between two consecutive similar points (in this case two crests) is called the wavelength.*
- *This is the length of the wave pulse.*
- *Between what other points is can a wavelength be measured?*

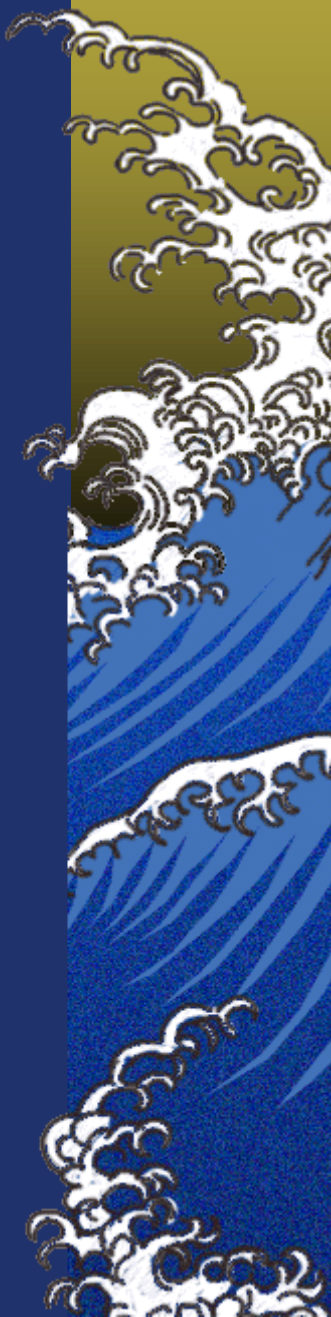
Anatomy of a Wave

- *What else can we determine?*
- *We know that things that repeat have a frequency and a period. How could we find a frequency and a period of a wave?*



Wave frequency

- *We know that frequency measure how often something happens over a certain amount of time.*
- *We can measure how many times a pulse passes a fixed point over a given amount of time, and this will give us the frequency.*

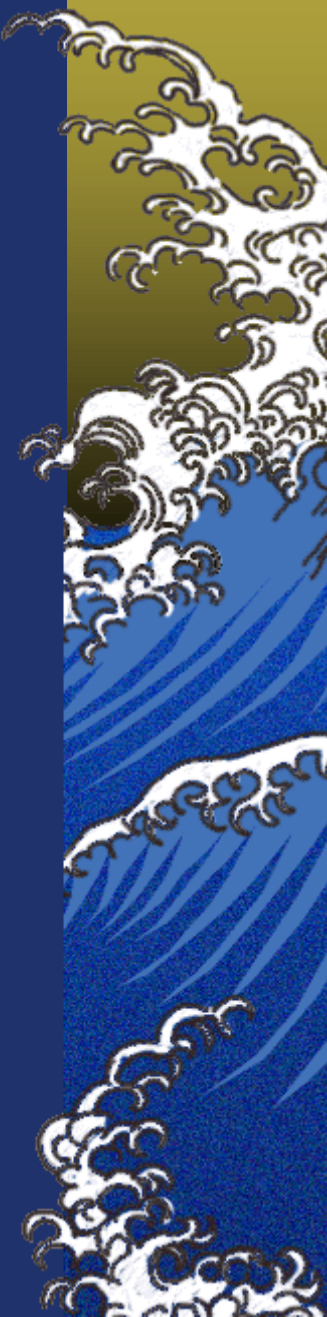


Wave frequency

- *Suppose I wiggle a slinky back and forth, and count that 6 waves pass a point in 2 seconds. What would the frequency be?*
  - *3 cycles / second*
  - *3 Hz*
  - *we use the term Hertz (Hz) to stand for cycles per second.*

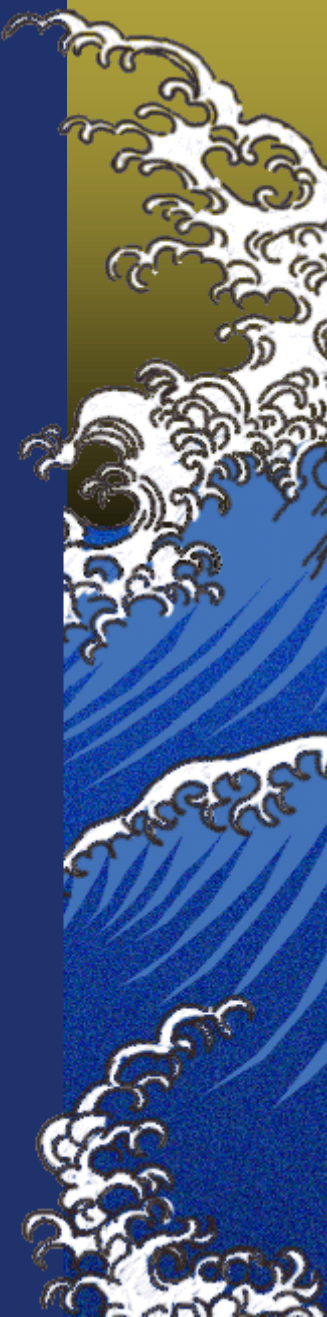
Wave Period

- *The period describes the same thing as it did with a pendulum.*
- *It is the time it takes for one cycle to complete.*
- *It also is the reciprocal of the frequency.*
- $T = 1 / f$
- $f = 1 / T$
- *let's see if you get it*.



Wave Speed

- *We can use what we know to determine how fast a wave is moving.*
- *What is the formula for velocity?*
  - *velocity = distance / time*
- *What distance do we know about a wave*
  - *wavelength*
- *and what time do we know*
  - *period*



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Wave Speed

- *so if we plug these in we get*
  - *velocity =*

    length of pulse /

    time for pulse to move pass a fixed point
  - $v = \lambda / T$
  - *we will use the symbol λ to represent wavelength*

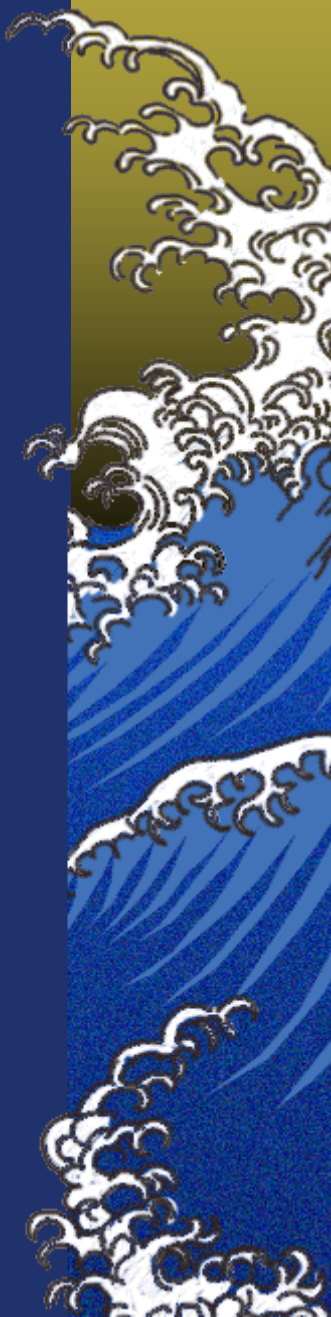
copy this

Wave Speed

- $v = \lambda / T$
- *but what does T equal*
  - $T = 1 / f$
- *so we can also write*
  - $v = f \lambda$
  - *velocity = frequency * wavelength*
- *This is known as the wave equation.*
- *examples*

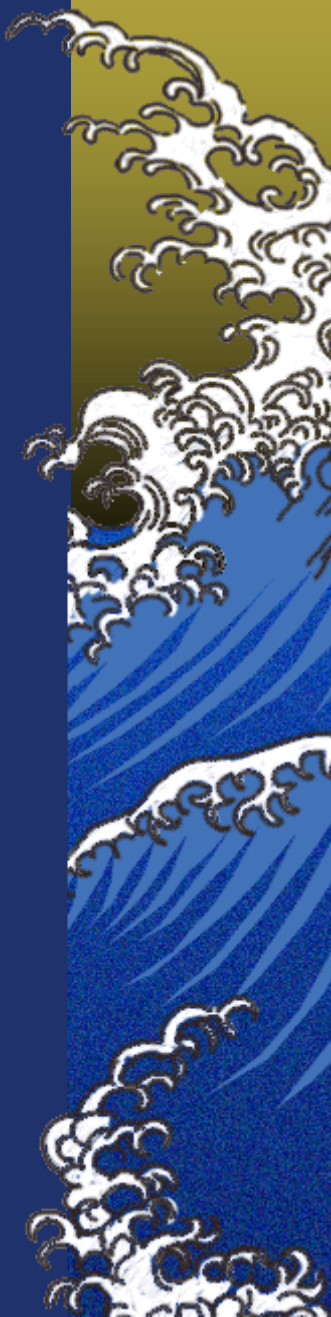
Wave Behavior

- *Now we know all about waves.*
- *How to describe them, measure them and analyze them.*
- *But how do they interact?*



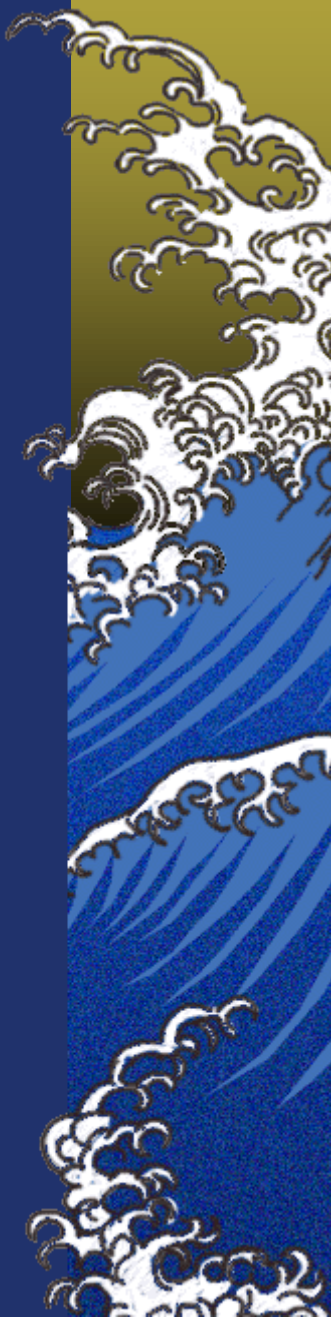
Wave Behavior

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

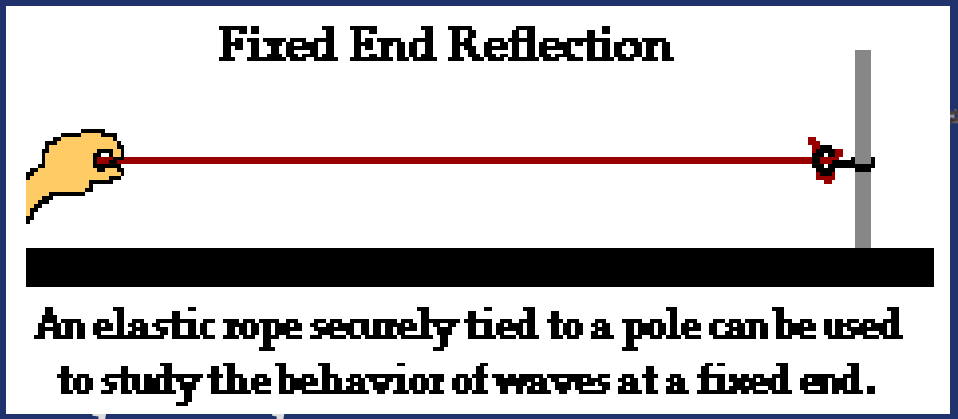


Boundary Behavior

- *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.*

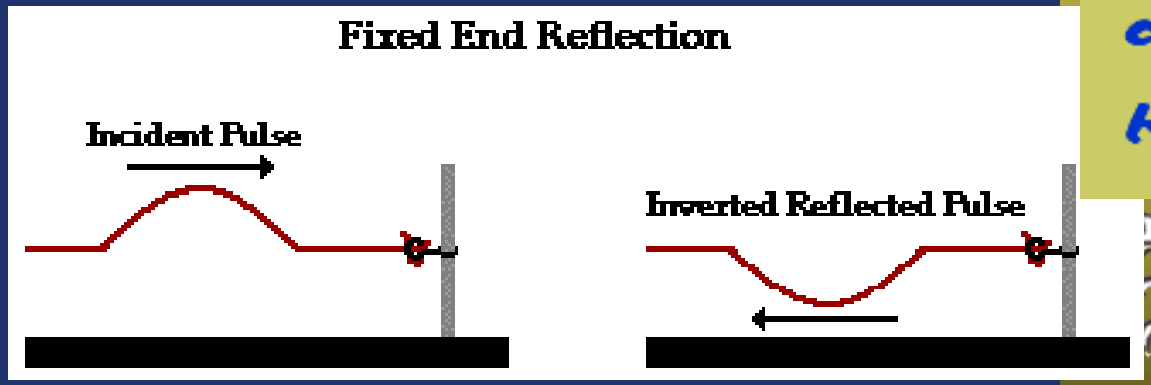


Fixed End



- *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?*

Fixed End



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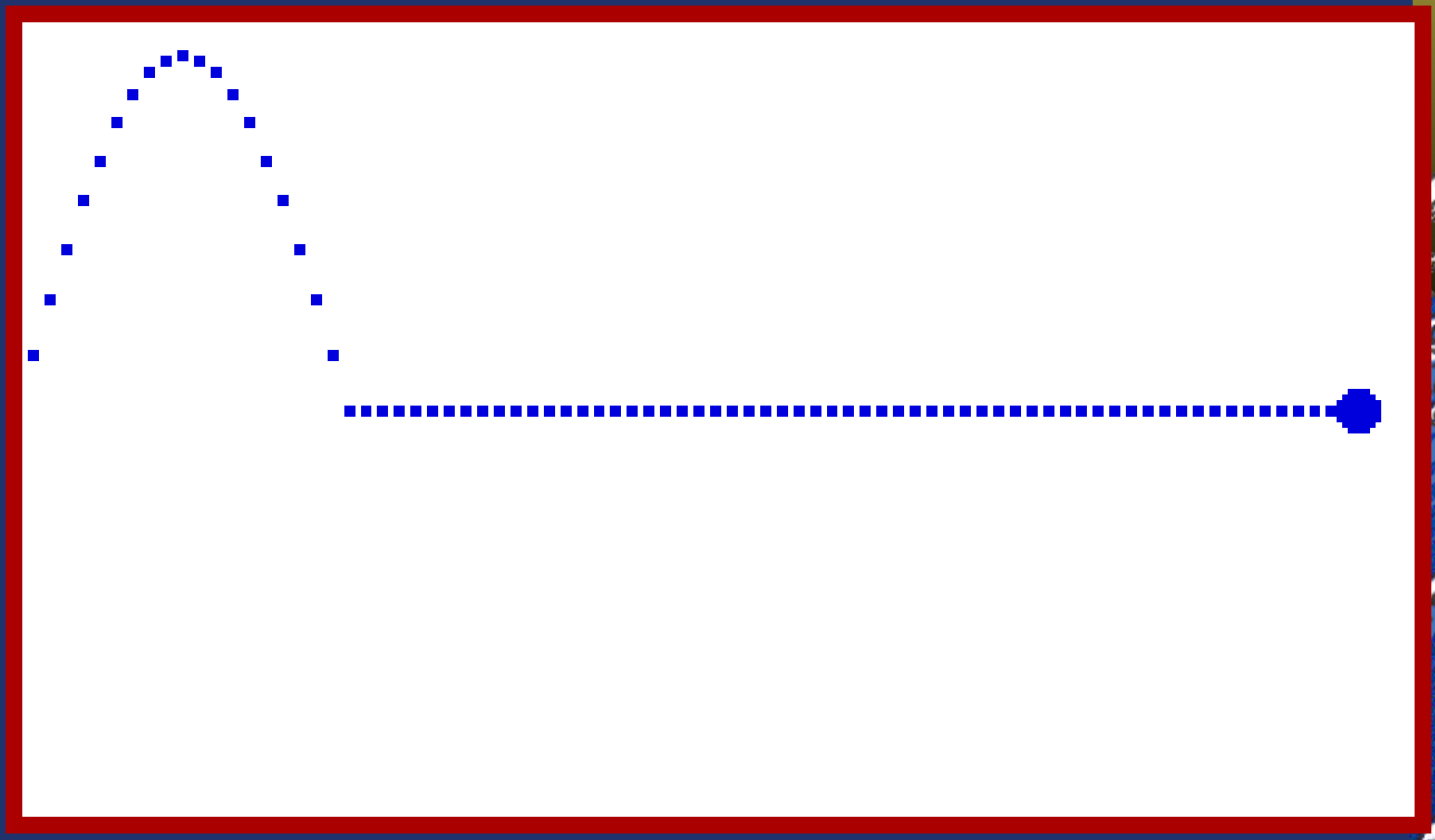
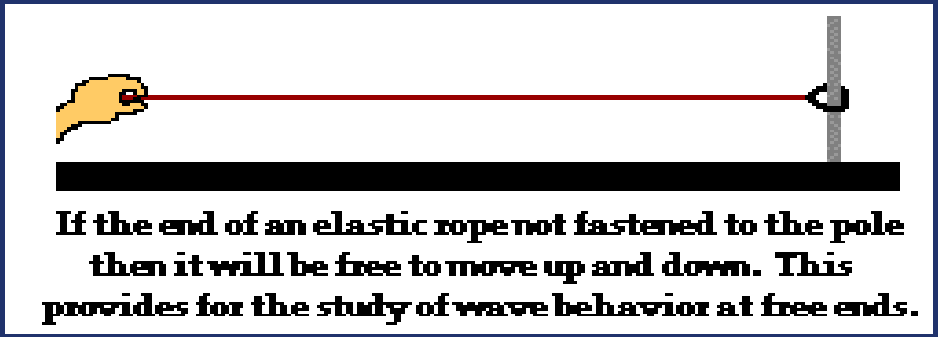
- *Here the incident pulse is an upward pulse.*
- *The reflected pulse is upside-down. It is inverted.*
- *The reflected pulse has the same speed, wavelength, and amplitude as the incident pulse.*

Fixed End Animation



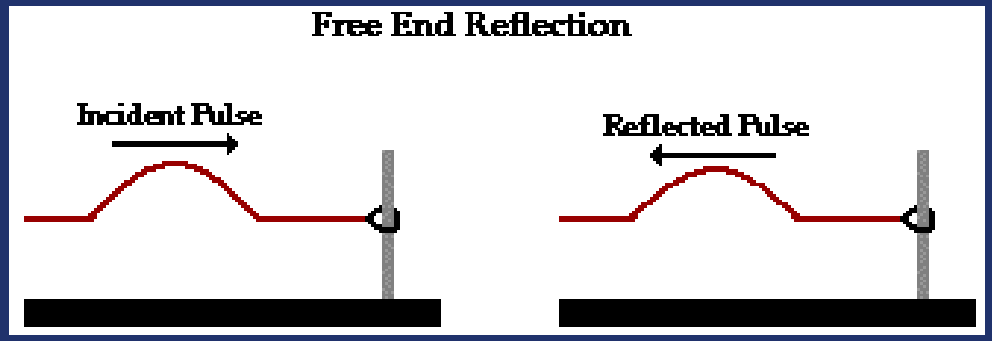
Free End



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.

- *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?*

Free End



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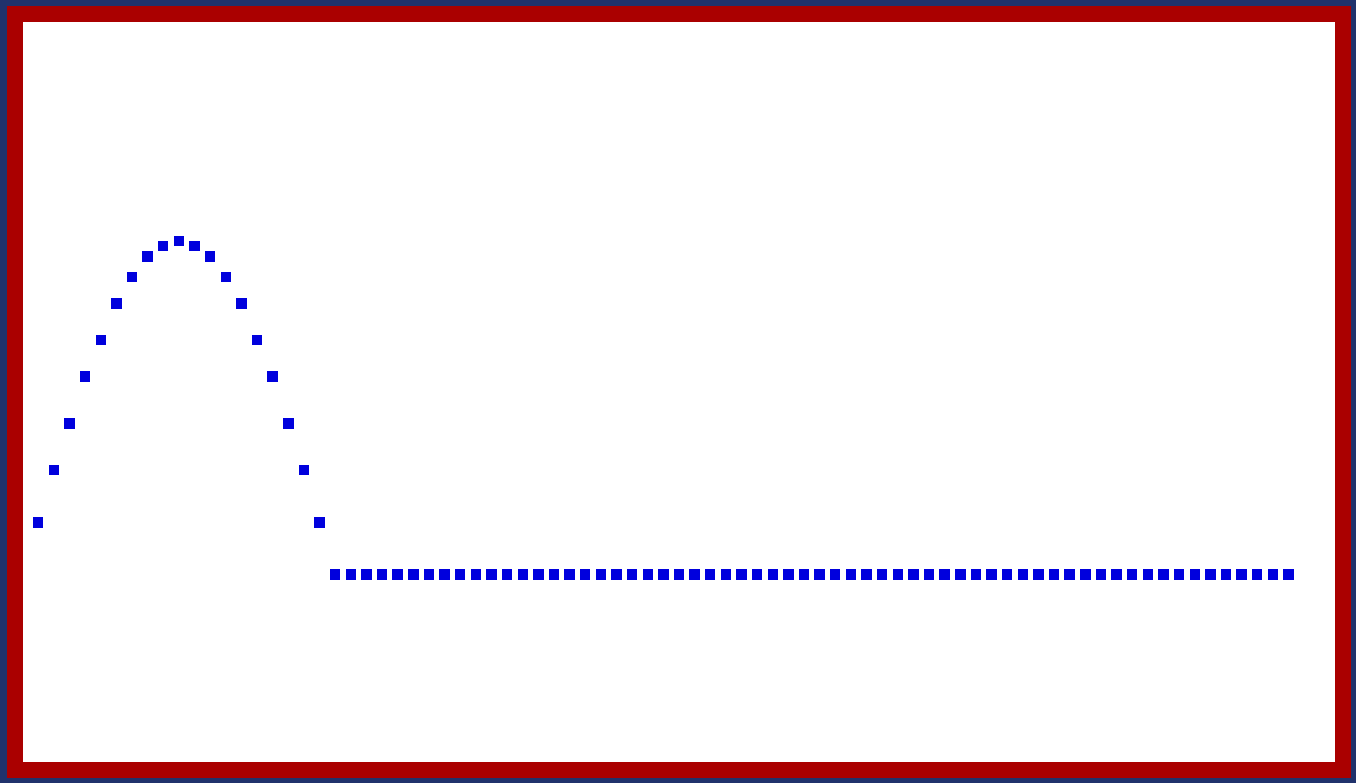
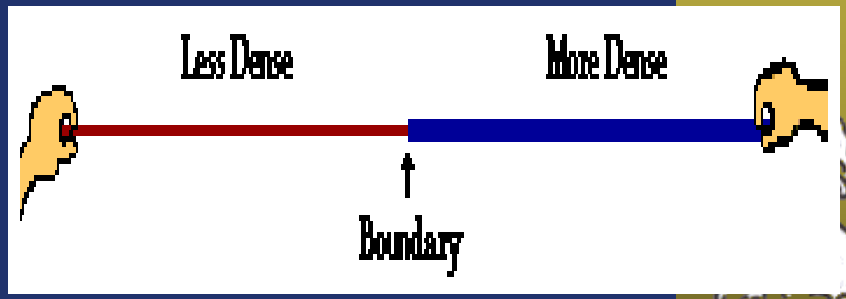
- *Here the reflected pulse is not inverted.*
- *It is identical to the incident pulse, except it is moving in the opposite direction.*
- *The speed, wavelength, and amplitude are the same as the incident pulse.*

Free End Animation

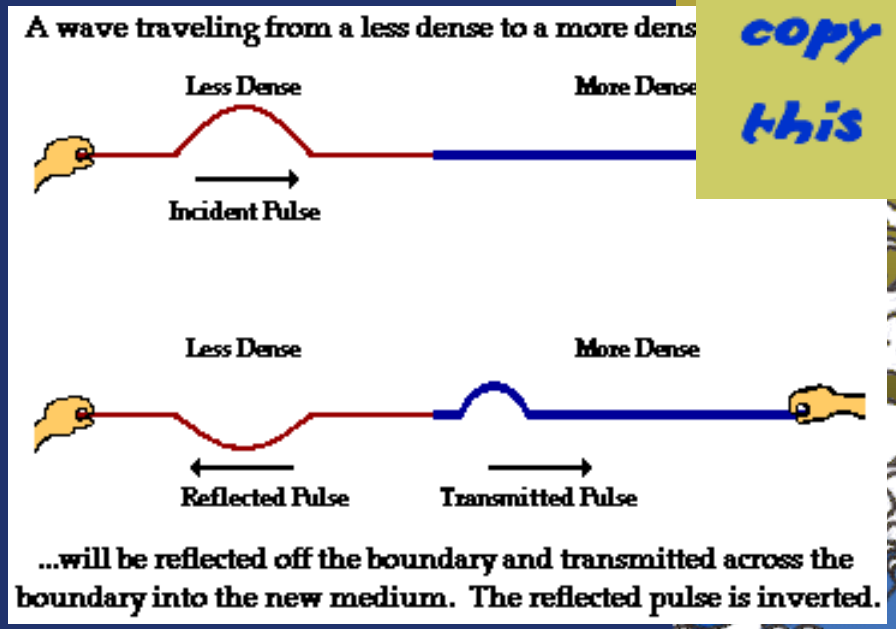


Change in Medium



- *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



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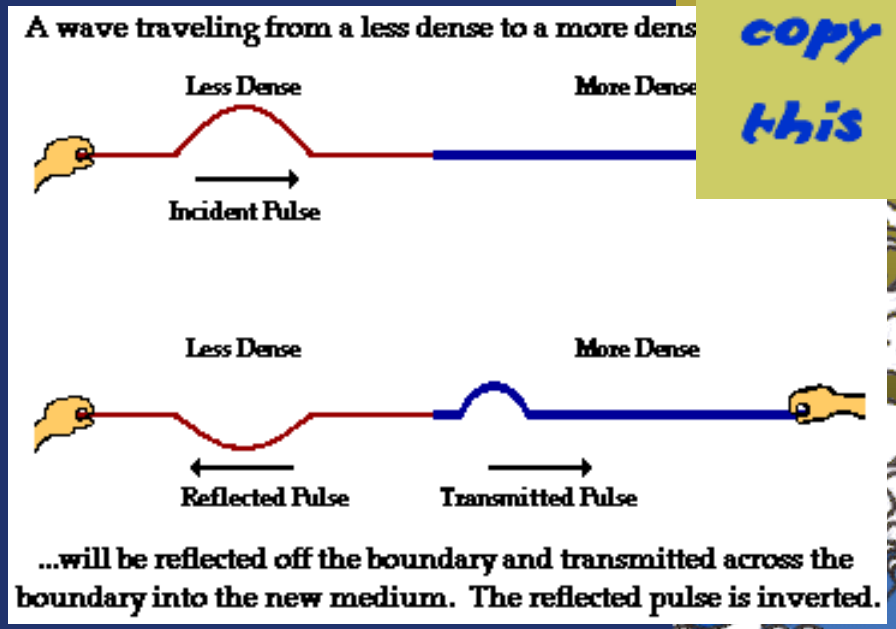
- *In this situation part of the wave is reflected, and part of the wave is transmitted.*
- *Part of the wave energy is transferred to the more dense medium, and part is reflected.*
- *The transmitted pulse is upright, while the reflected pulse is inverted.*

Change in Medium



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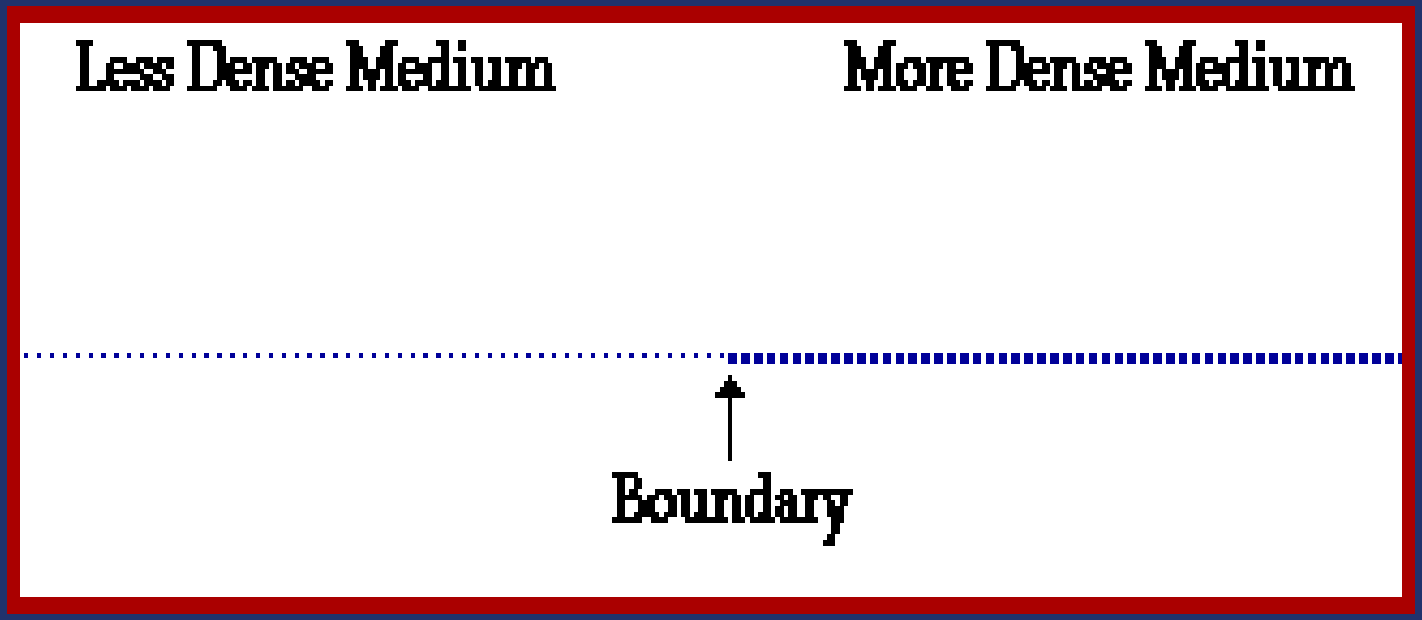
- *The speed and wavelength of the reflected wave remain the same, but the amplitude decreases.*
- *The speed, wavelength, and amplitude of the transmitted pulse are all smaller than in the incident pulse.*

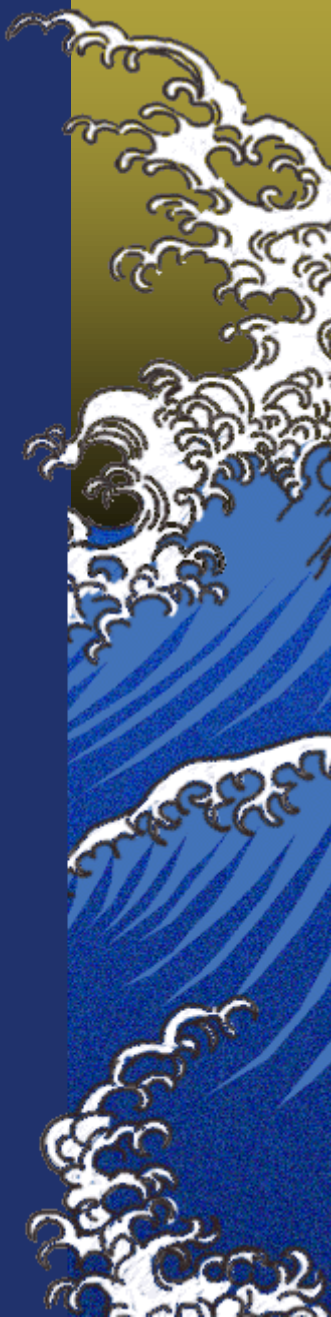
Change in Medium Animation



Test your understanding

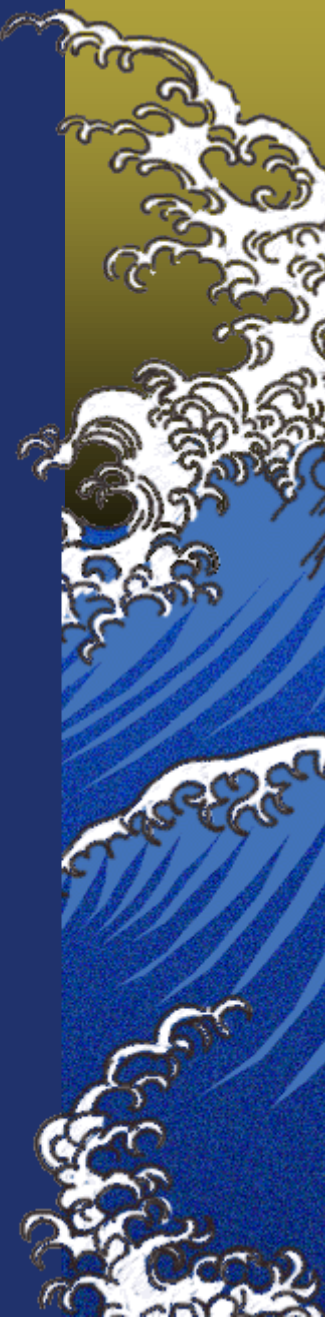
Wave Interaction

- *All we have left to discover is how waves interact with each other.*
- *When two waves meet while traveling along the same medium it is called INTERFERENCE.*



Constructive Interference

- *Let's consider two waves moving towards each other, both having a positive upward amplitude.*
- *What will happen when they meet?*



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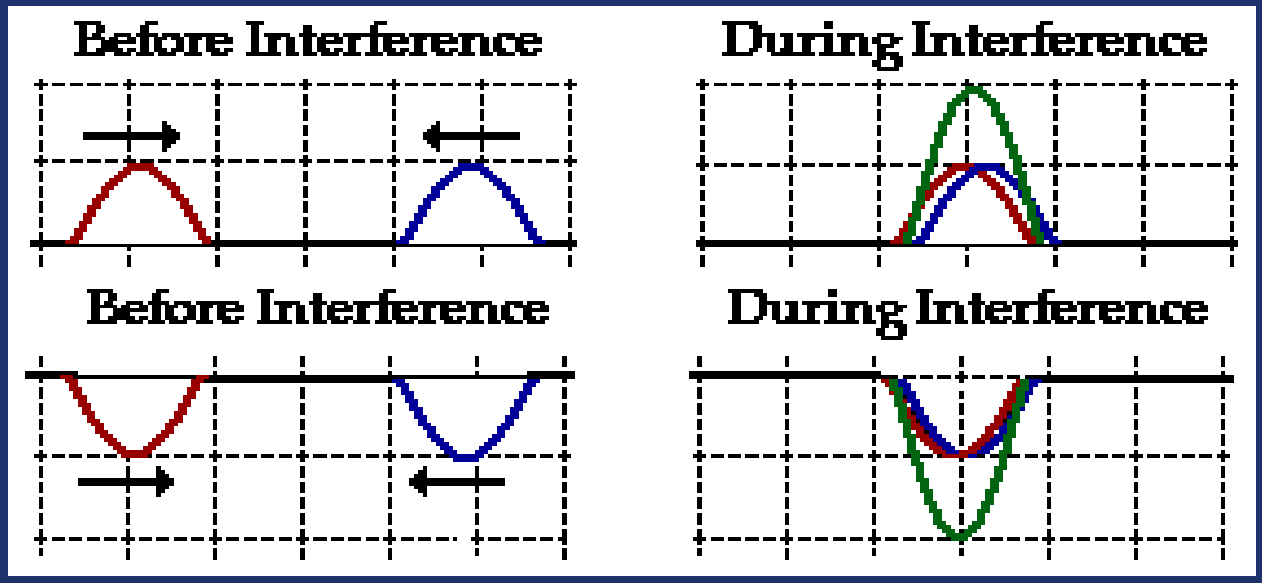
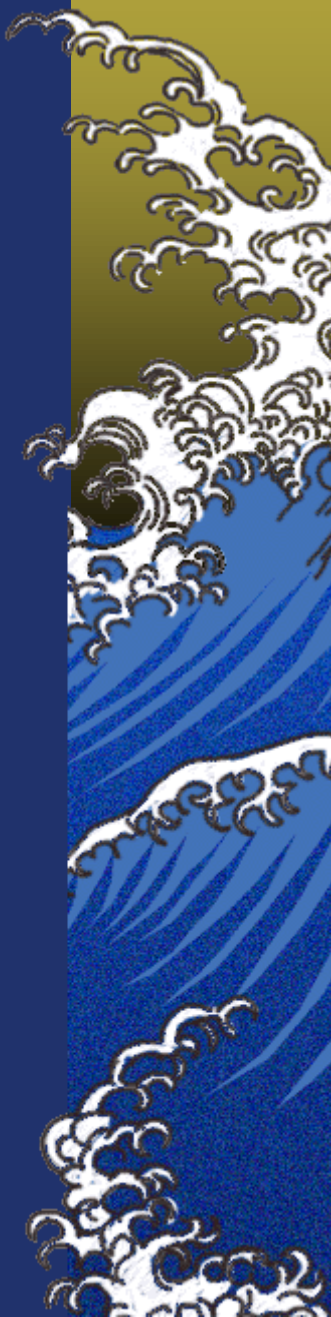
Constructive Interference

- *They will ADD together to produce a greater amplitude.*
- *This is known as CONSTRUCTIVE INTERFERENCE.*



Destructive Interference

- *Now let's consider the opposite, two waves moving towards each other, one having a positive (upward) and one a negative (downward) amplitude.*
- *What will happen when they meet?*



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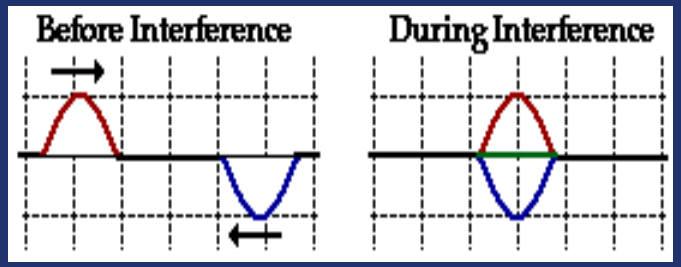
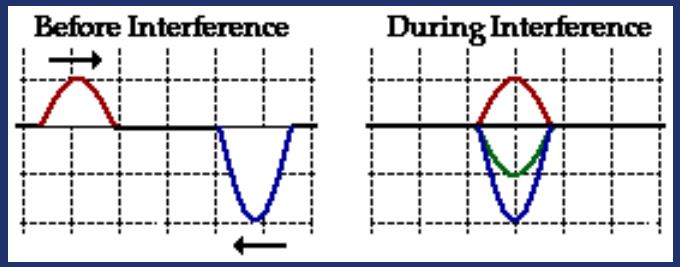
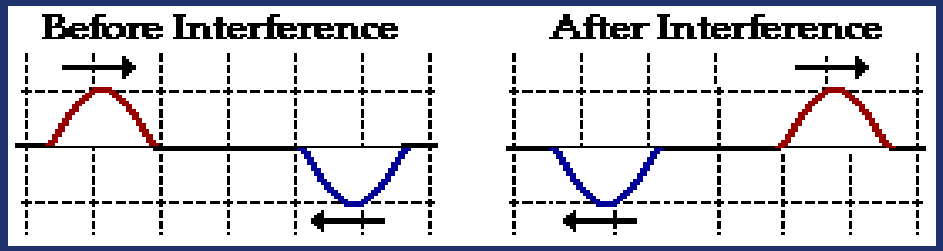
Destructive Interference

- *This time when they add together they will produce a smaller amplitude.*
- *This is know as DESTRUCTIVE INTERFERENCE.*

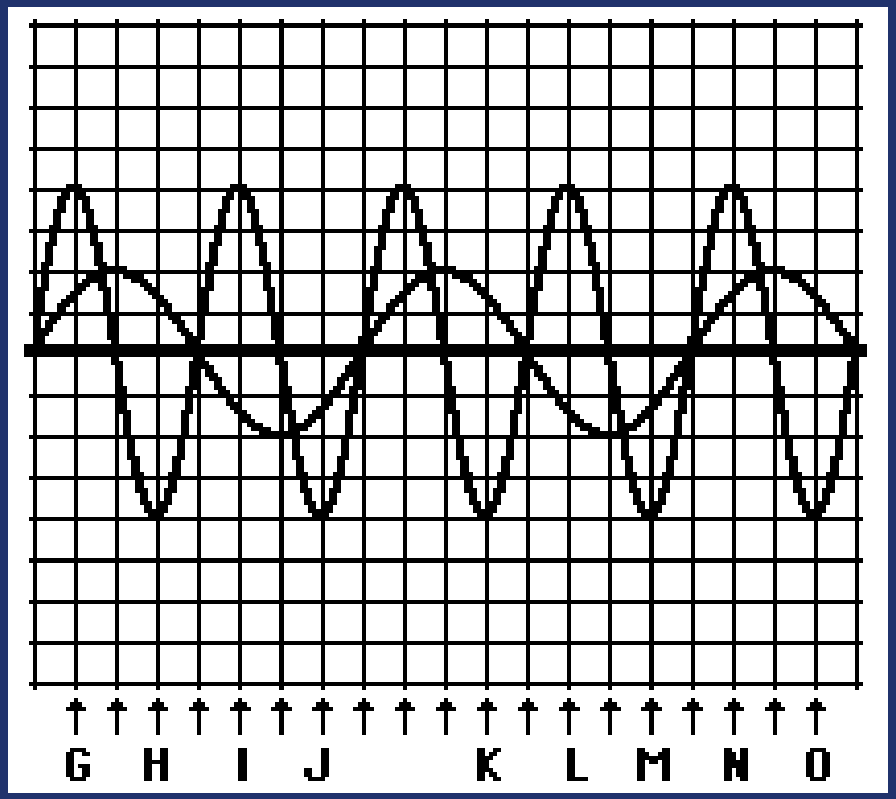






Check Your Understanding

- *Which points will produce constructive interference and which will produce destructive interference?*



- *Constructive*
  - *G, J, M, N*
- *Destructive*
  - *H, I, K, L, O*