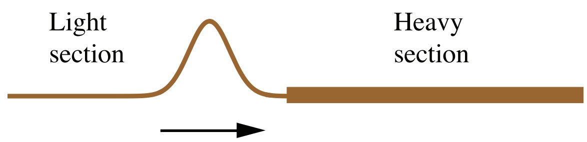
Learning Goals:

F.15a Use superposition to show the resultant wave when two waves overlap.

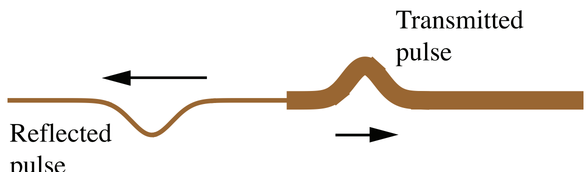
1) Explain the difference between the speed of a transverse wave traveling down a cord and the speed of a tiny piece of the cord.

2) What kind of waves (transverse or longitudinal) do you think will travel down the length of a horizontal metal rod if you strike its end (a) vertically from above and (b) horizontally parallel to its length?

3) When a sinusoidal wave pulse crosses the boundary between two sections of rope (please see the figure shown below), the frequency does not change (although the wavelength and velocity do change). Explain why the frequency doesn't change.

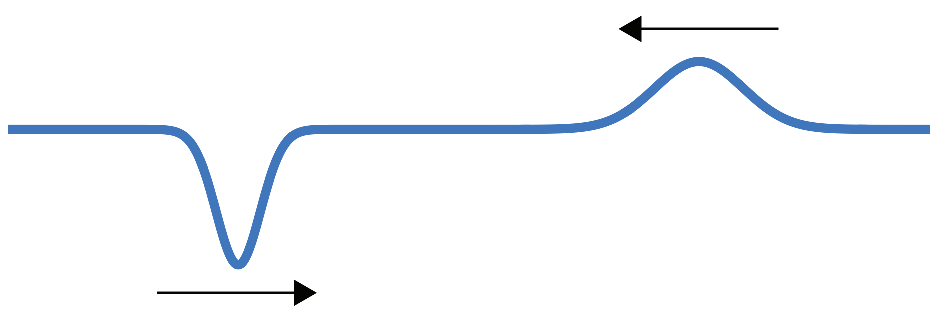


(a)



(b)

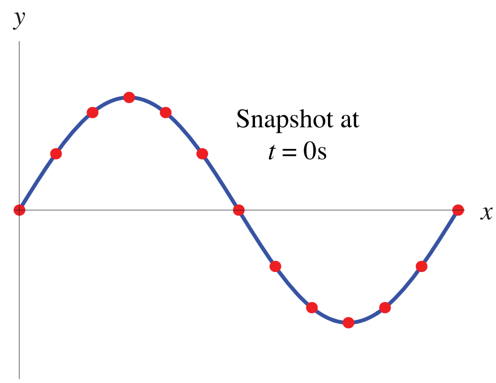
4) The two pulses shown in the figure below are moving toward each other.



(a) Sketch the shape of the string at the moment they directly overlap.

(b) Sketch the shape of the string a few moments later.

5) The figure on the next page shows a snapshot of a piece of a wave at a time $t = 0$ s. Make four sketches of this picture and use a dotted line to sketch what each pulse would look like at a slightly later time (a time that is small compared to the time it would take the pulse to move a distance equal to its own width but large enough to see a change in the shape of the string) for the following four cases.



(a) The wave is a traveling wave moving to the right.

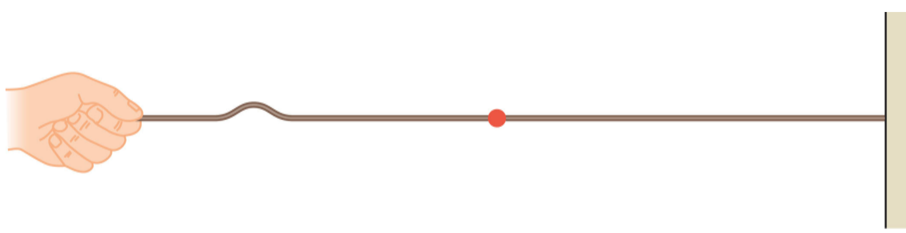
(b) The wave is a traveling wave moving to the left.

(c) The wave is a standing wave with a displacement that is increasing with time.

(d) The wave is a standing wave with a displacement that is decreasing with time.

On each picture, draw arrows to show the velocity of the marked points at time $t = 0$ s.

6) A long, taut string is attached to a distance wall as shown in the figure below. A demonstrator moves her hand and creates a very small amplitude pulse that reaches the wall in a time t_1. A small red dot is painted on the string halfway between the demonstrator's hand and the wall. For each situation below, state which of the actions 1–10 listed (taken by itself) will produce the desired results. For each question, *more than one answer may be correct*. If so, give them all.



Tell how, if at all, the demonstrator can repeat the original experiment to produce:

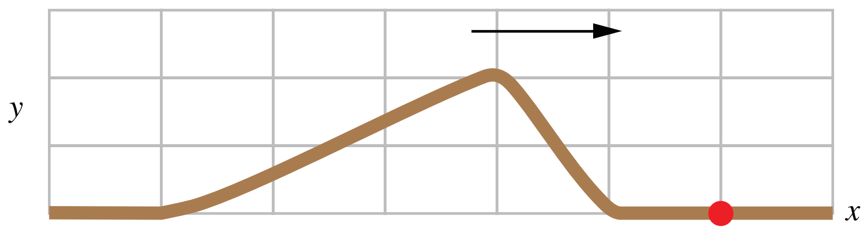
(a) A pulse that takes a longer time to reach the wall.

(b) A pulse that is wider than the original pulse.

(c) A pulse that makes the red dot travel a farther distance than in the original experiment.

1. Move her hand more quickly but still only up and down once and still by the same amount.
2. Move her hand more slowly but still only up and down once and still by the same amount.
3. Move her hand a larger distance but up and down in the same amount of time.
4. Move her hand a smaller distance but up and down in the same amount of time.
5. Use a heavier string of the same length under the same tension.
6. Use a lighter string of the same length under the same tension.
7. Use a string of the same density, but decrease the tension.
8. Use a string of the same density, but increase the tension.
9. Put more force into the wave.
10. Put less force into the wave.

7) The figure below shows a photograph of a pulse moving to the right on a taut string. The red dot to the right of the figure is a small bead of negligible mass attached to the string.



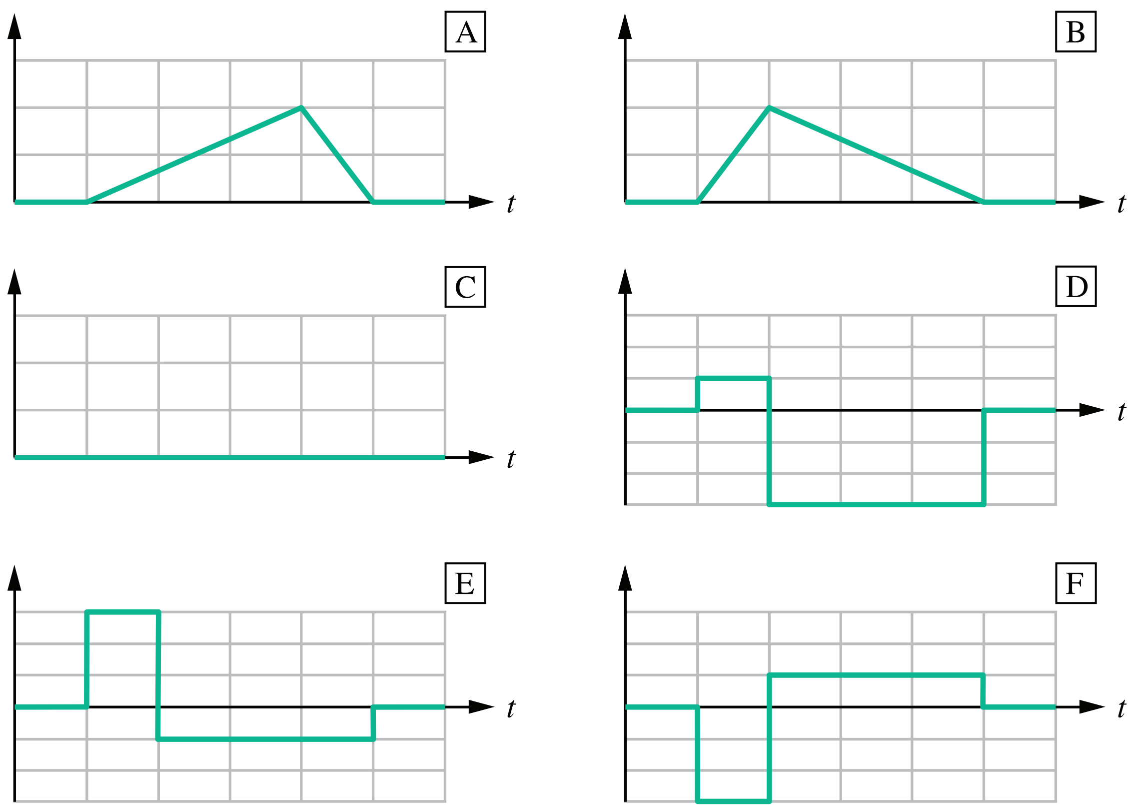
For each of the following quantities, select the letter of the graph in the figure below that could provide a correct graph of the quantity (if the vertical axis were assigned the proper units) and write it on your answer sheet. If none of the graphs would work, write N.

(a) The vertical (up-down) displacement of the bead.

(b) The vertical velocity of the bead.

(c) The horizontal (left-right) displacement of the bead.

(d) The horizontal velocity of the bead.



8) Show that

(a) $y(x,t) = Y\cos\left[k\left(x - v\,t\right)\right]$

(b) $y(x,t) = Y\cos\left[2\pi\left(\dfrac{x}{\lambda} - f\,t\right)\right]$

(c) $y(x,t) = Y\cos\left[\omega\left(\dfrac{x}{v} - t\right)\right]$

(d) $y(x,t) = Y\cos\left[2\pi\left(\dfrac{x}{\lambda} - \dfrac{t}{T}\right)\right]$

are all equivalent to $y(x,t) = Y\cos\left(k\,x - \omega\,t\right)$

9) The equation for the displacement of a transverse wave traveling along a very long string is

$$y(x,t) = \left(6.0\,\mathrm{cm}\right)\cos\left[\left(0.020\pi\,\frac{\mathrm{rad}}{\mathrm{cm}}\right)x + \left(4.0\pi\,\frac{\mathrm{rad}}{\mathrm{s}}\right)t\right]$$

where *x* and *y* are expressed in centimeters and *t* is in seconds. Determine

(a) the amplitude,

(b) the wavelength (spatial period),

(c) the temporal frequency,

(d) the speed,

(e) and the direction of propagation of the wave.

(f) What is the transverse displacement at x = +3.5 cm when t = 0.26 s.