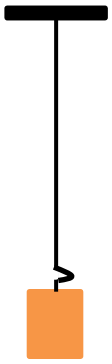
Wave examples

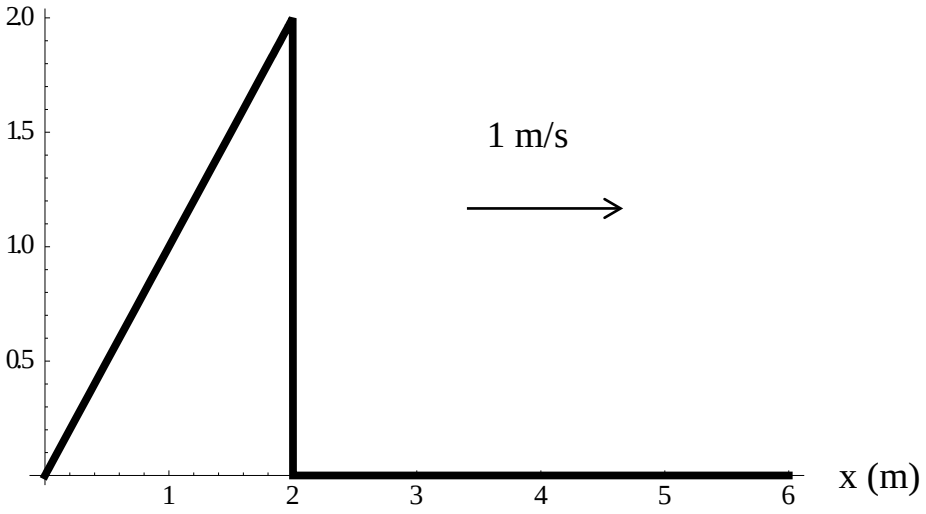


Example 1

A 5 kg mass is hanging on a 2-m long string attached to a ceiling. The mass of the string is 4 g. The string is plucked where it is attached to the mass. How long does the pulse take to reach the ceiling? Take g = 10 m/s^2.

Example 2

D(x, t=0) in mmm



The figure shows a snapshot graph made at t = 0 s of a wave moving to the right at 1 m/s.

1) Is the wave transverse or longitudinal? Can you tell?

2) Draw:
   a) The snapshot graph D(x, t= 4s).

   b) The snapshot graph D(x, t= -2 s).

   c) The history graph D(x = 0 m, t) at x = 0 m.

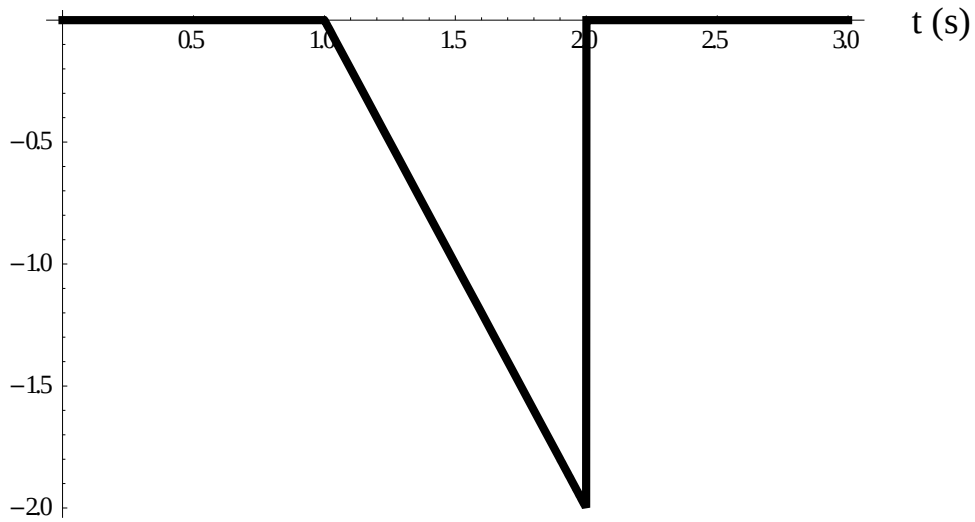
   d) The history graph D(x = 4 m, t) at x = 4 m.

   e) Show that for any traveling wave, D(x, t) must be of the form f(x − a t). What is the physical meaning of the constant a? Give the function f for the above example.

Example 3

Wave traveling to the left at 1m/s

D(x = 0, t) in mmm

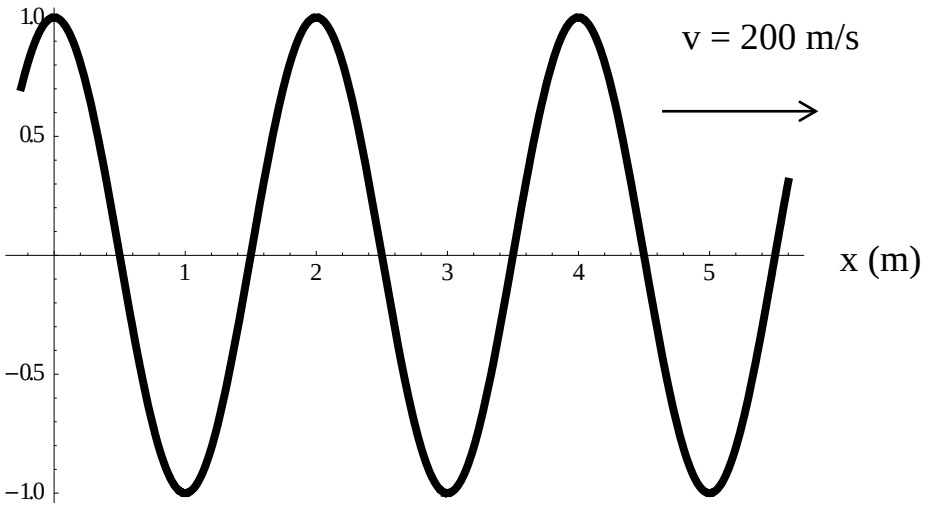


The figure shows a history graph made at x = 0 m. Draw

a) The history graph D(x = 1 m, t)
b) The snapshot graph D(x, t = 1 s)

Example 4

D(x, t = 0) in mmm

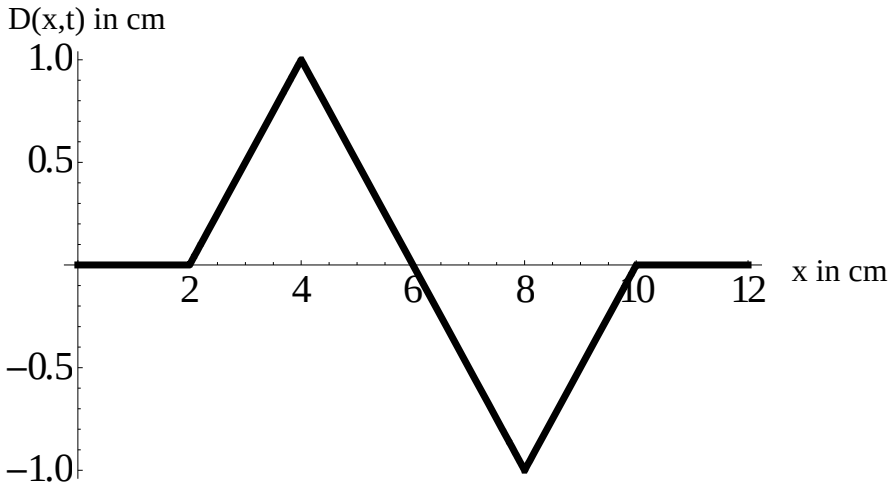


The figure shows a snapshot graph made at t = 0 m.

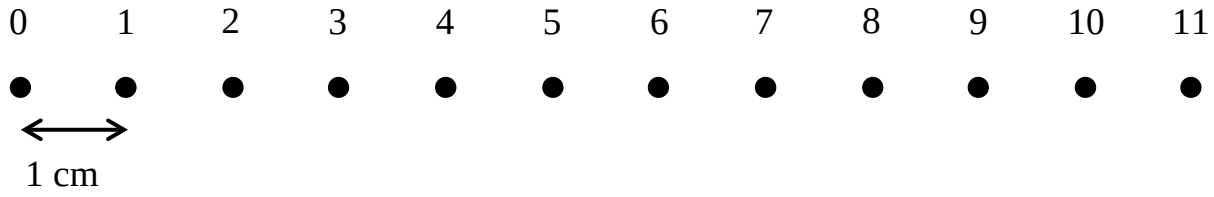
a) Find the wavelength λ, the period T and the frequency f.
b) Find the wavenumber k and the angular frequency ω.
c) Draw snapshots graphs of the wave at t = T/4 and t = T/2.
d) Draw the graph if the wavelength is halved. Also, if the wavelength is changed, do the period and the frequency change as well?
e) Draw the graph is the frequency is halved and the speed is unchanged. Does the wavelength change?
f) Draw the graph if the phase constant is increased by π radians.
g) Draw the graph is the tension is halved (assuming the wave is on a string) and the frequency is unchanged.

Example 5

A longitudinal wave on a spring has the following snapshot graph at some time t.

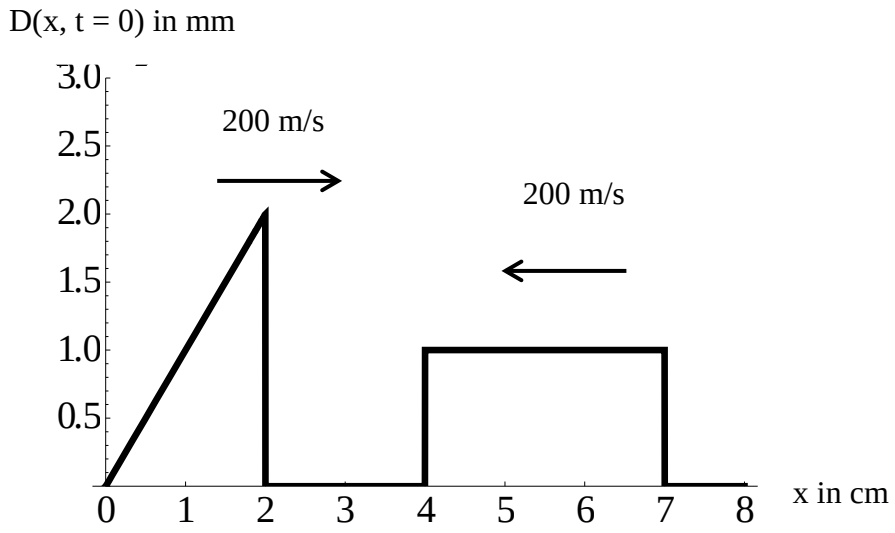


The locations of the coils of the spring at rest are given on the diagram below. Draw a diagram to show the locations of the coils of the spring at time t.



Example 6 (superposition)

The snapshot graph below shows two transverse pulses traveling in opposite directions on a string at t = 0s. Draw the snapshot graphs at t = 10 ms and at t = 15 ms.



Example 7 (standing wave)

1) Two transverse waves in a long string have wave functions given by

$$D_1 = 0.015\ m \cos\left(\frac{x}{2} - 40\ t\right)$$

$$D_2 = 0.015\ m \cos\left(\frac{x}{2} + 40\ t\right)$$

where D_1, D_2 and x are in meters and t is in seconds.

   a) Find the equation $D(x,t) = D_1 + D_2$ of the resulting wave.
   b) Determine the locations of the nodes and of the antinodes.
   c) What is the maximum transverse position of the string at position x = 0.4 m?

2) Two speakers are driven in phase by a common oscillator at 800 Hz and face each other at a distance of 1.25 m. Locate the points along a line joining the two speakers where air displacements are the least. Use v_{sound} = 343 m/s.

Example 8 (beats)

In certain ranges of a piano keyboard, more than one string is tuned to the same note to provide extra loudness. For example, the note at 110 Hz has two strings at this frequency. If one string slips from its normal tension of 600 N to 540 N, what beat frequency is heard when the hammer strikes the two strings simultaneously.

Example 9 (Doppler effect)

Standing at a crosswalk, you hear a frequency of 560 Hz from the siren of an approaching ambulance. After the ambulance passes, the observed frequency of the siren is 480 Hz. Determine the ambulance's speed from these observations.