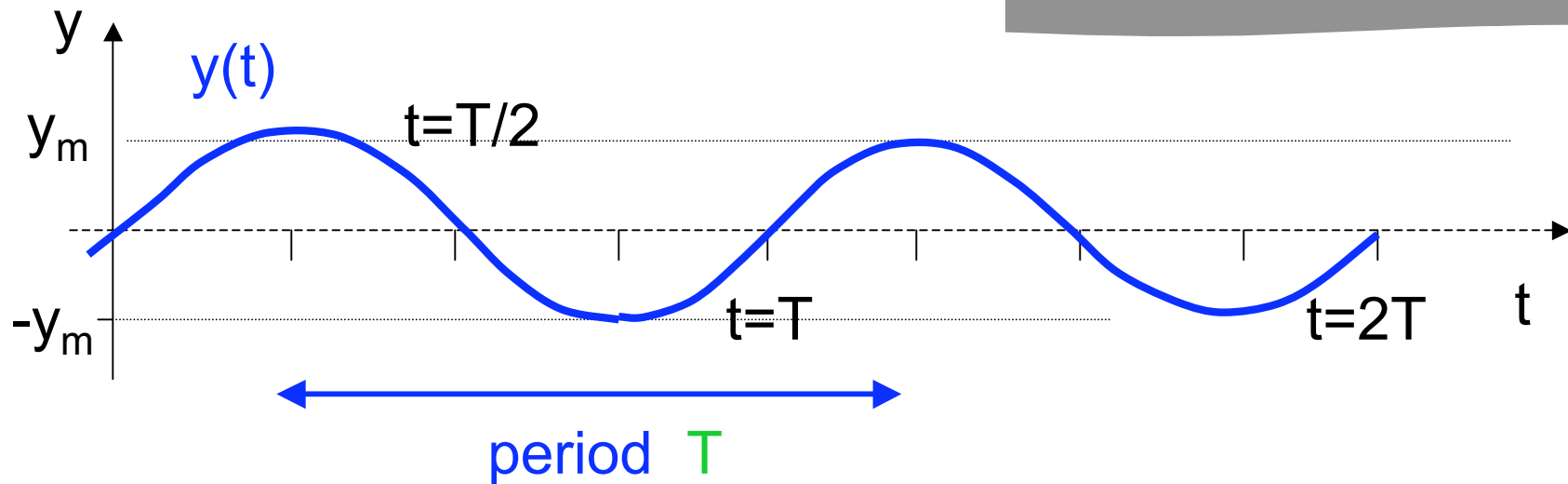
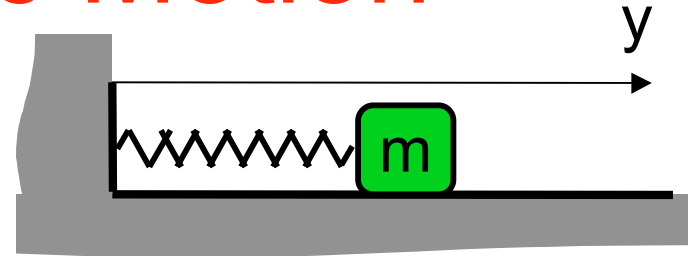


Waves



Simple Harmonic Motion

$$y(t) = y_m \sin(\omega t)$$

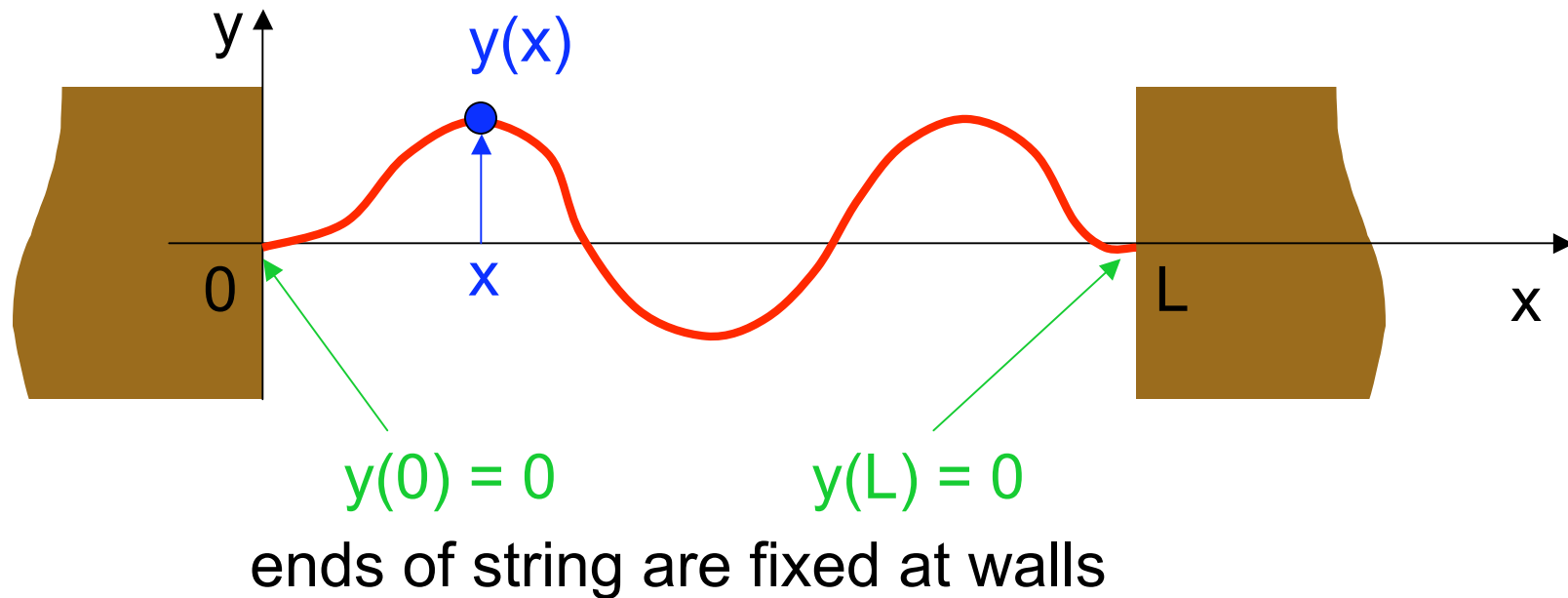


$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

T	period	[s]
f	frequency	[$s^{-1} = \text{Hz}$]
ω	angular frequency	[rad/s]

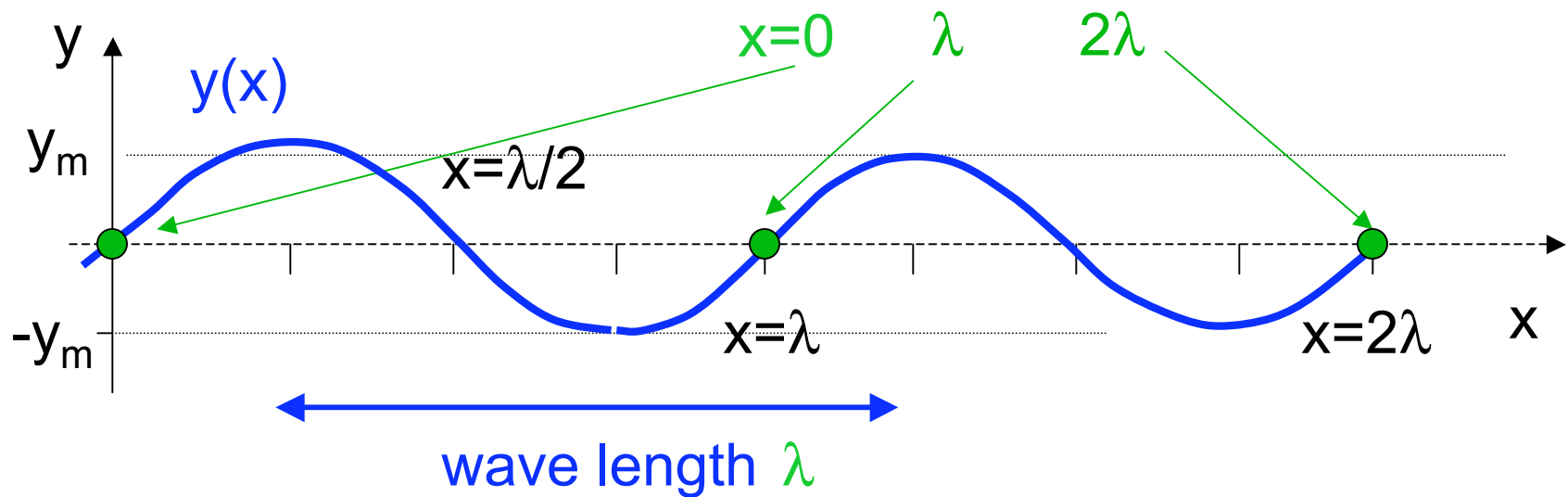
Describing a String

At any instant we describe the state of the string using the function $y(x)$



A sinusoidal pattern

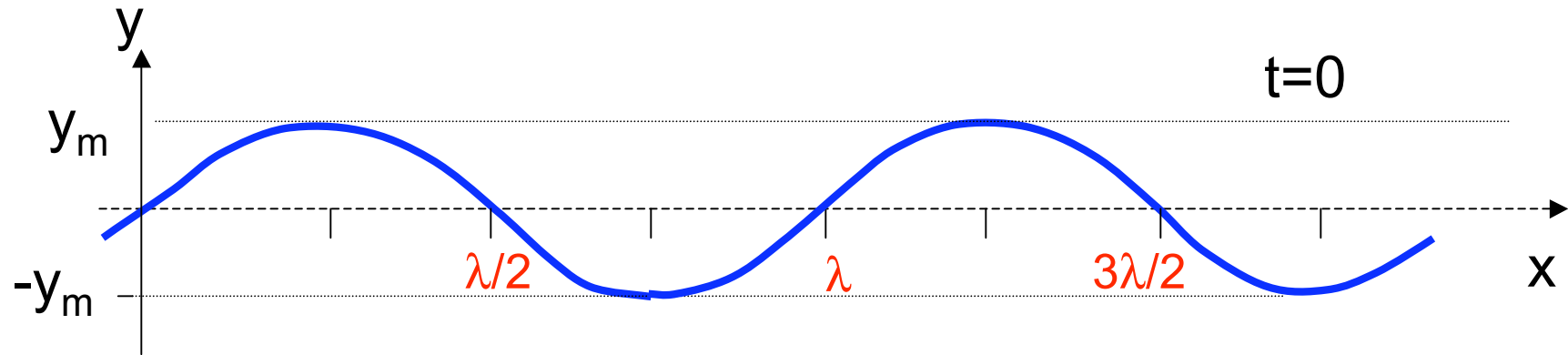
$$y(x) = y_m \sin(kx) = y_m \sin(2\pi x / \lambda) \quad \text{one instant}$$



$$k = \frac{2\pi}{\lambda}$$

λ	wave length	[m]
-	?	[m ⁻¹]
k	wave number	[rad/m]

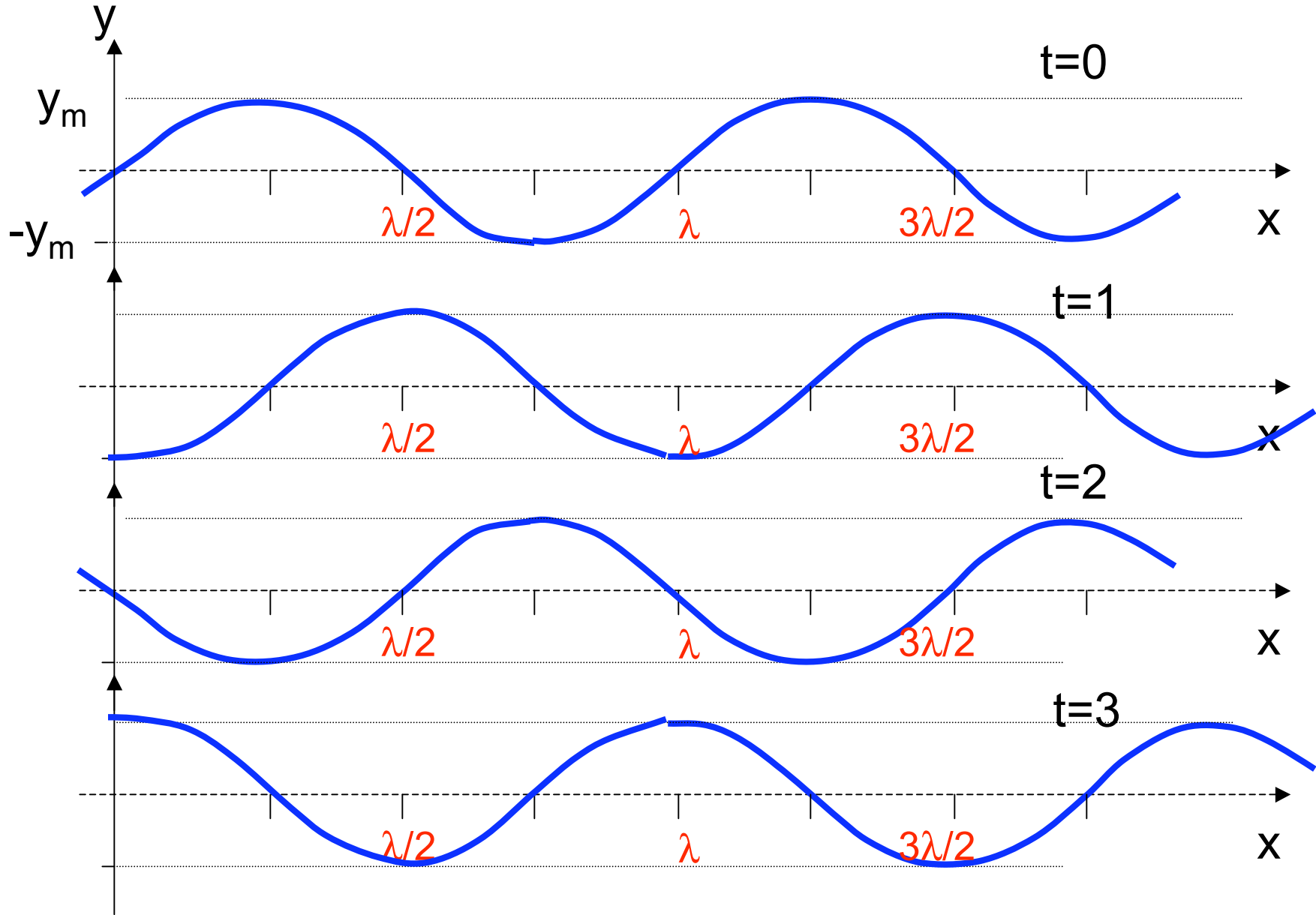
Traveling shape $y(x,t) = y_m \sin[kx - \omega t]$



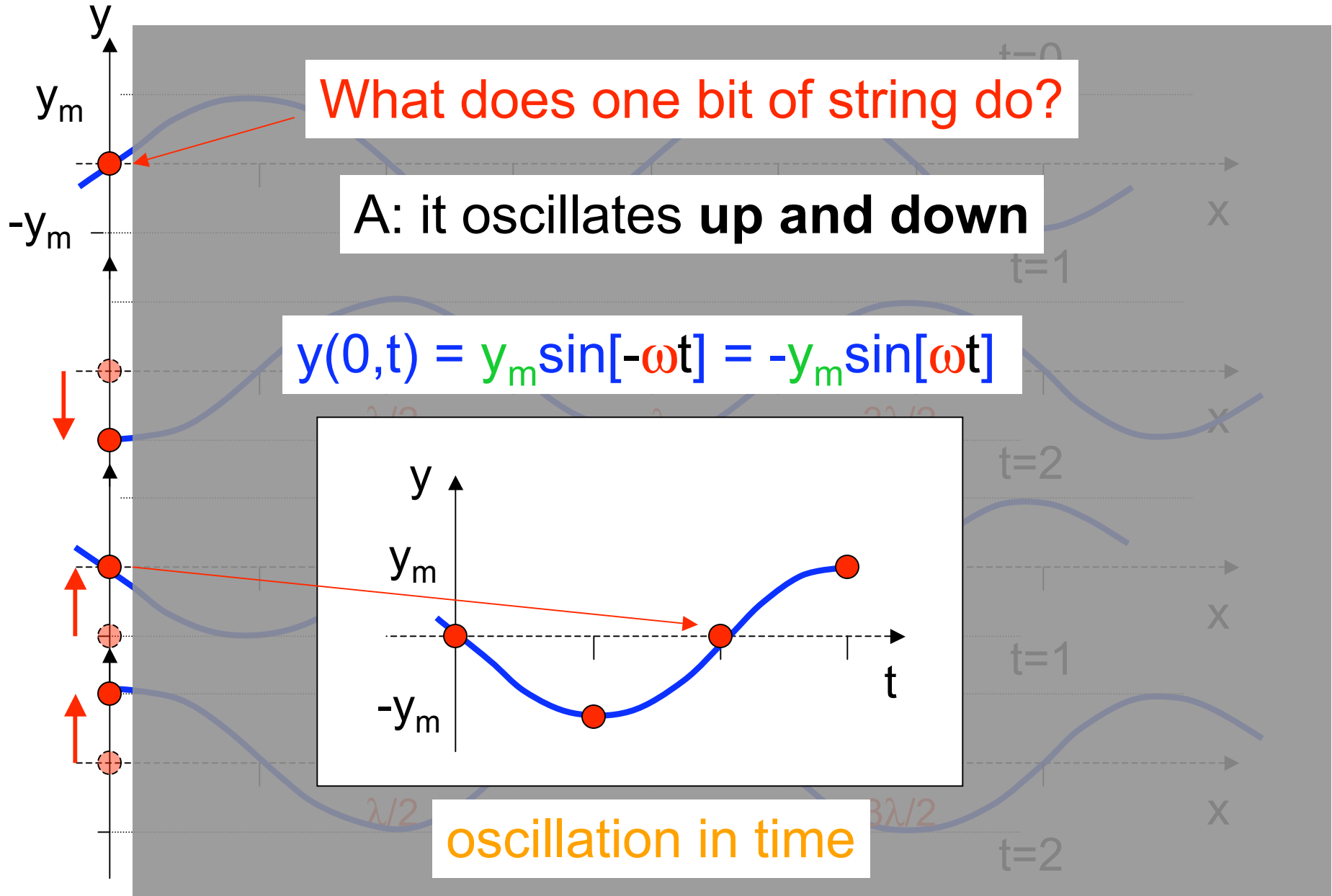
$y(x,0) = y_m \sin[kx]$ snap shot

oscillation in space

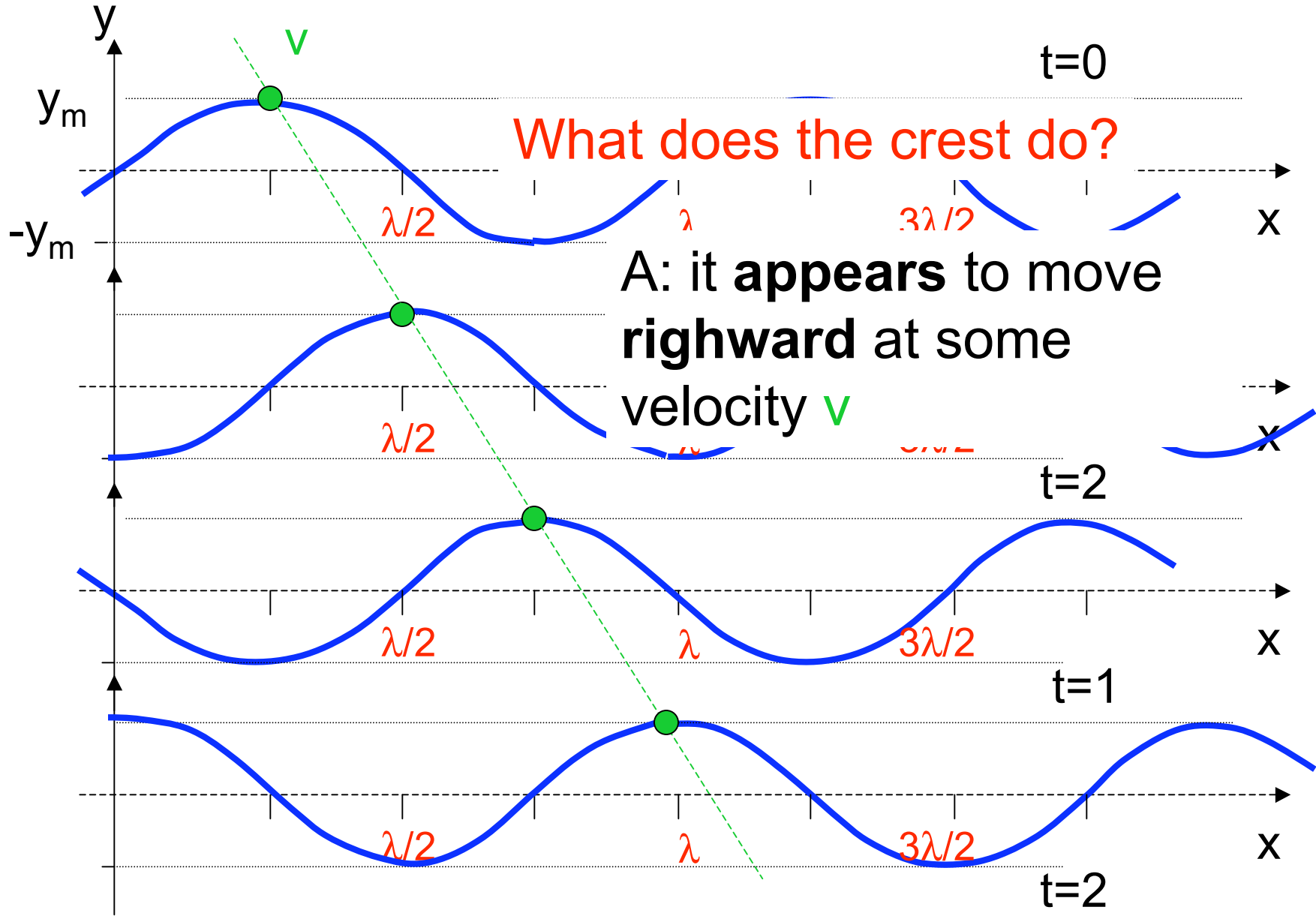
Traveling shape $y(x,t) = y_m \sin[kx - \omega t]$



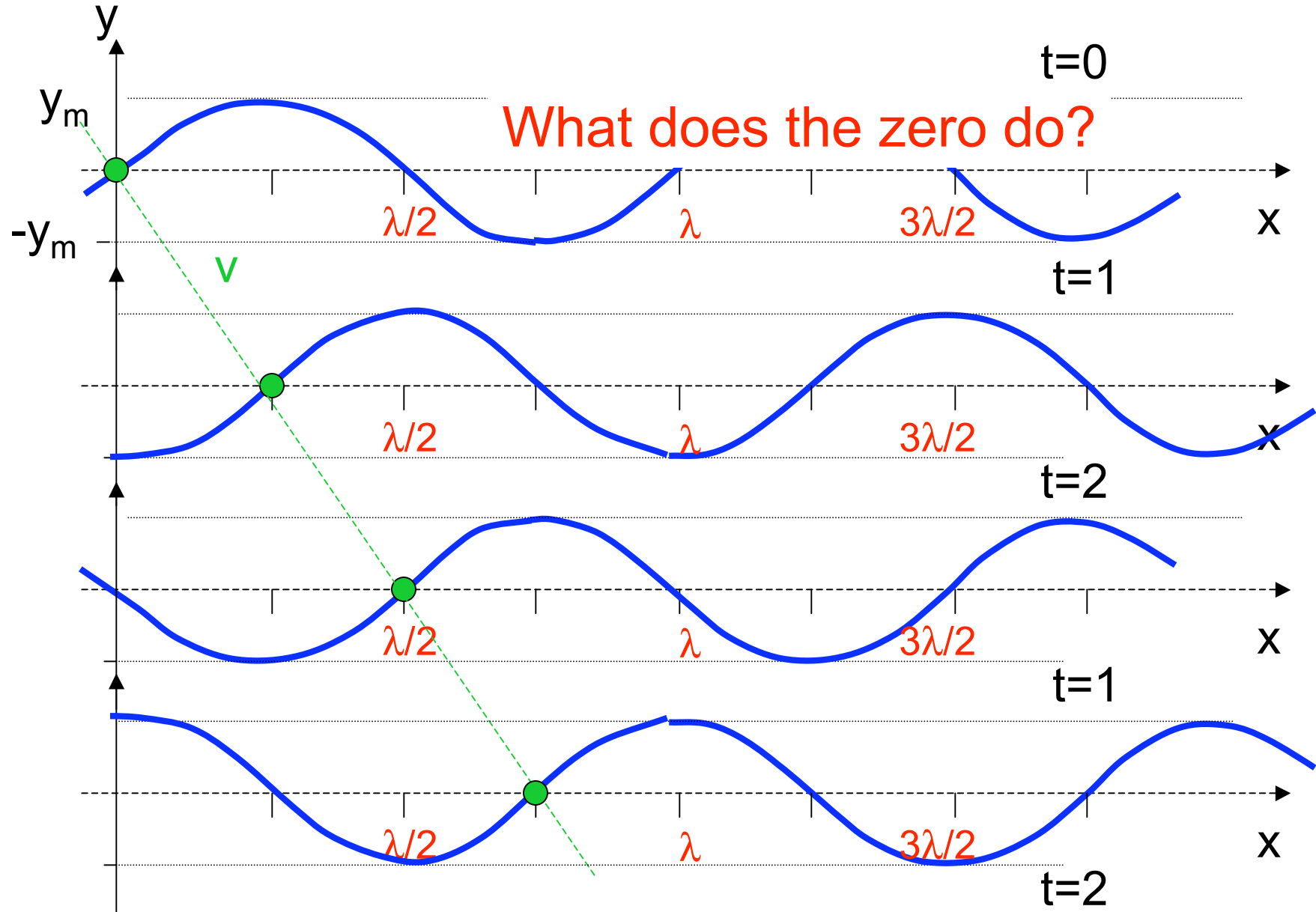
Traveling shape $y(x,t) = y_m \sin[kx - \omega t]$



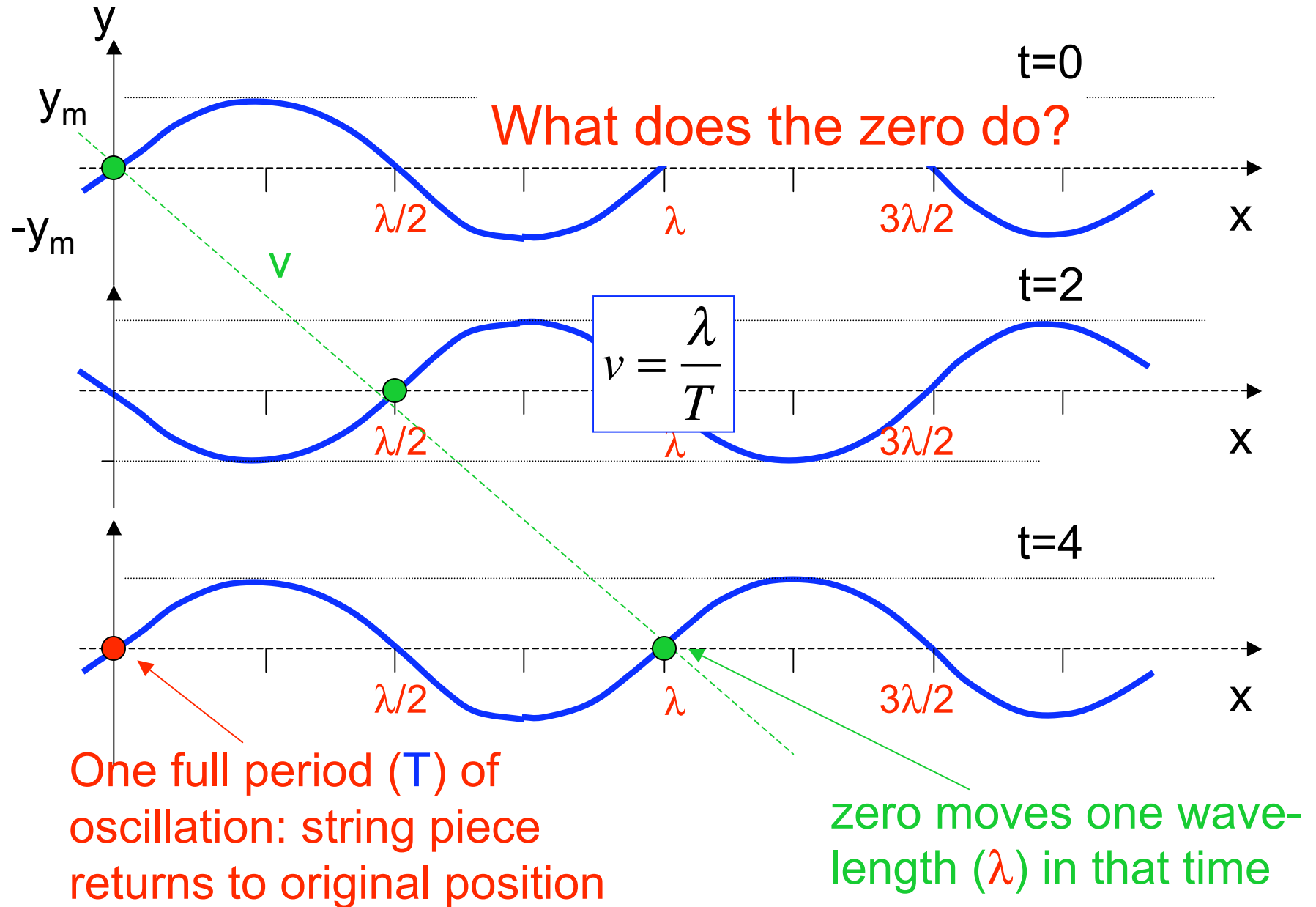
Traveling pattern $y(x,t) = y_m \sin[kx - \omega t]$



Traveling shape $y(x,t) = y_m \sin[kx - \omega t]$

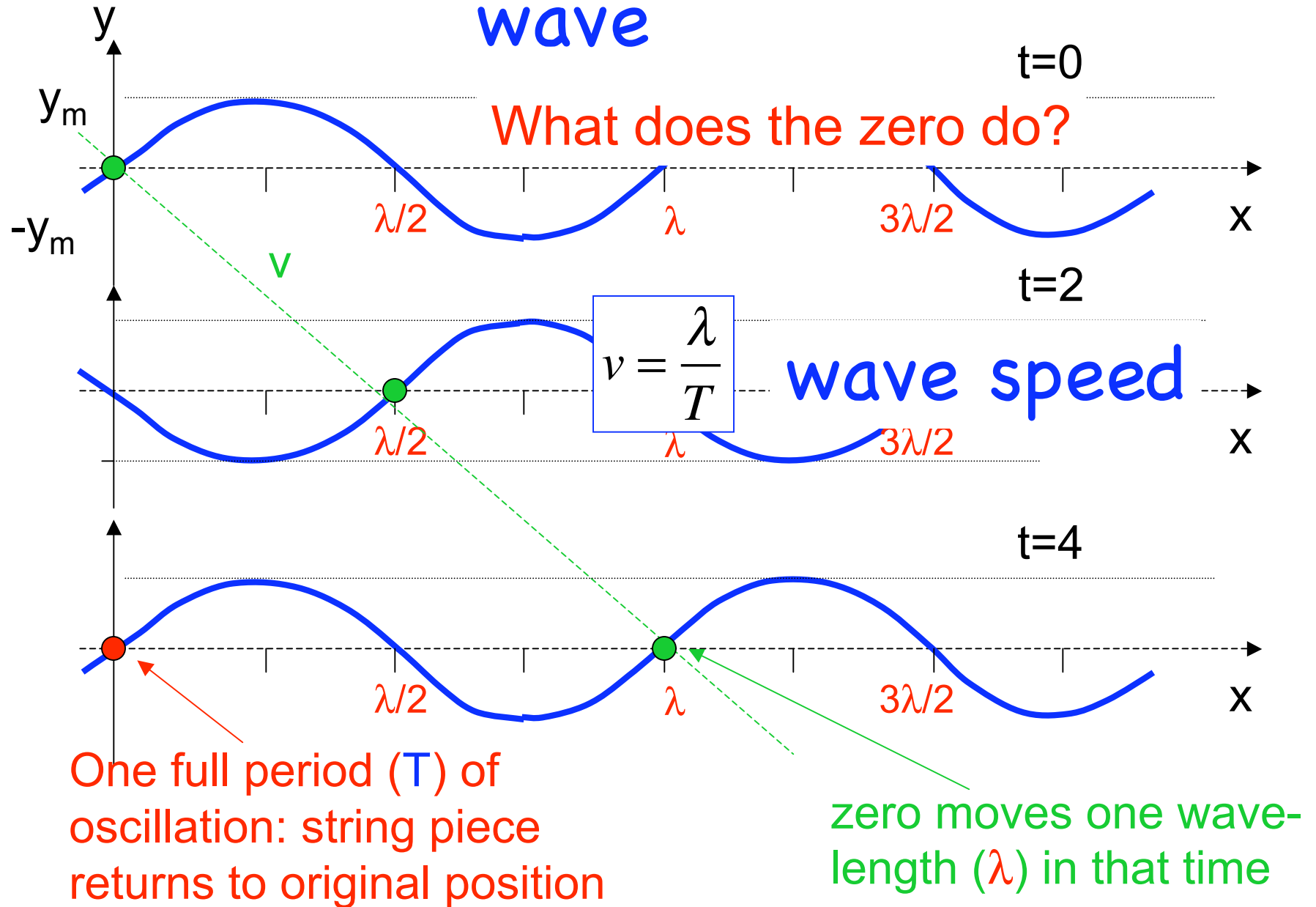


Traveling shape $y(x,t) = y_m \sin[kx - \omega t]$



Traveling ~~shape~~ wave

$$y(x,t) = y_m \sin[kx - \omega t]$$



The wave speed

relation between space & time sine waves

$$v = \frac{\lambda}{T} = \lambda f$$

= speed of the shape

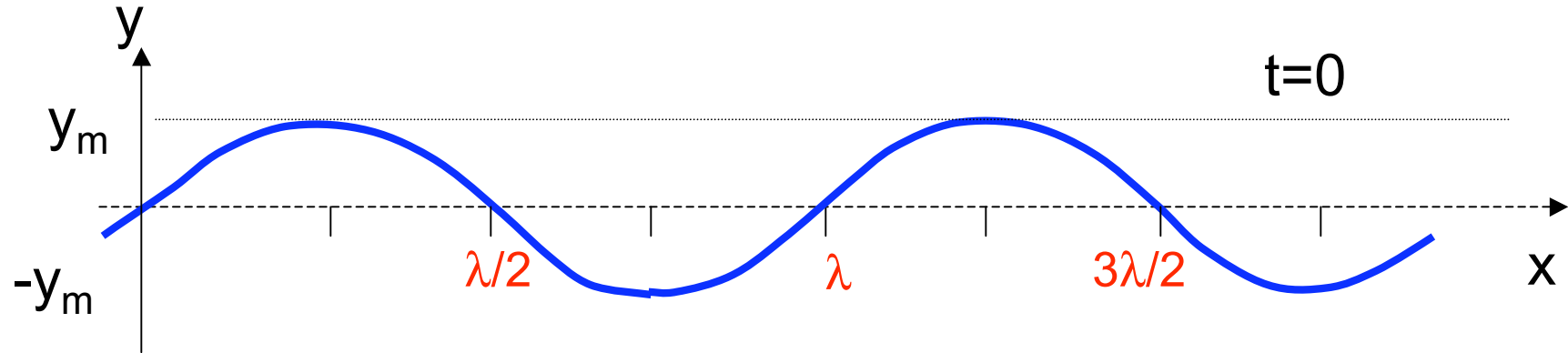
= speed of the zero

= speed of the crest

≠ speed of any **thing**

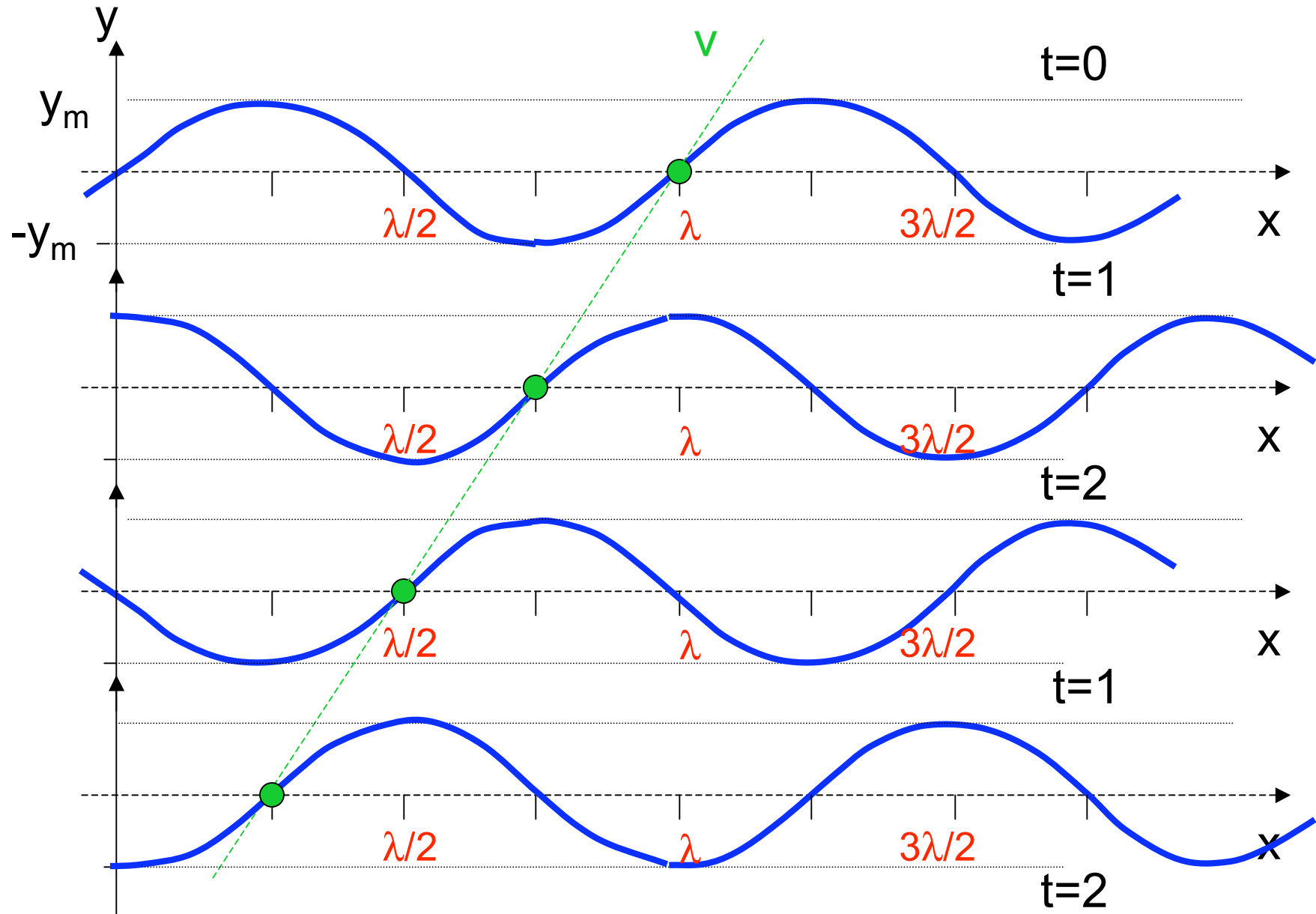
$$v = \frac{\lambda}{T} = \frac{\left(\frac{2\pi}{k}\right)}{\left(\frac{2\pi}{\omega}\right)} = \frac{\omega}{k}$$

Traveling pattern $y(x,t) = y_m \sin[kx + \omega t]$

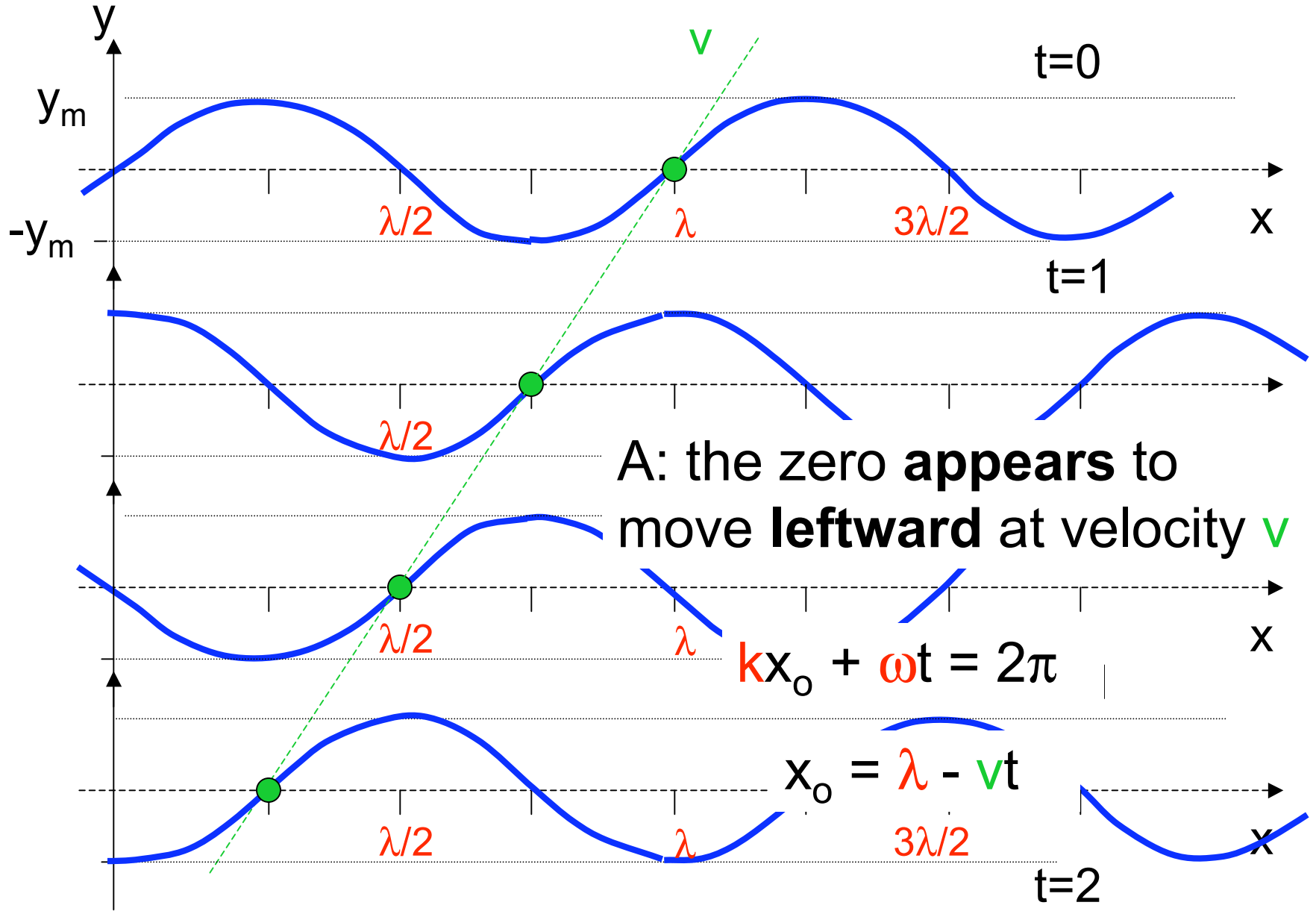


what happens next?

Traveling pattern $y(x,t) = y_m \sin[kx + \omega t]$



Traveling pattern $y(x,t) = y_m \sin[kx + \omega t]$



Periods & Wavelengths

$$y(t) = y_m \sin(\omega t)$$


$$y(x) = y_m \sin(kx)$$

ang. freq.: ω 

wave number: k

frequency: $f = \omega/2\pi$

frequency: ?

Period: $T = 2\pi/\omega$ 

wave length: $\lambda = 2\pi/k$

$$y(x,t) = y_m \sin(kx - \omega t)$$

$$v = \omega/k = \lambda/T$$

KGLT broadcasts (radio) waves whose frequency is $f=91.9$ MHz. Their wave speed is $v=3.0 \times 10^8$ m/s. What is the wavelength of these waves?

- A 0.31 m
- B 1.9 m
- C 3.3 m
- D 20 m
- E something else

A sinusoidal water wave moves across the surface of a pond. Its crests are separated by 6.0 m. A duck, floating in the middle of the pond, bobs up and down 5 times in 10 seconds as the wave passes it (i.e. 5 ups & 5 downs). What is the speed of the wave?

- A 0.60 m/s
- B 1.2 m/s
- C 3.0 m/s
- D 12 m/s
- E something else

A sinusoidal water wave moves across the surface of a pond from East to West at 3.0 m/s. A duck, floating in the middle of the pond, bobs up and down. Water waves are transverse. In which direction does the water beneath the duck move due to the wave?

- A Eastward
- B Westward
- C East & West
- D North & South
- E up & down

Speeds of different waves

light: 3.0×10^8 m/s

sound: 343 m/s

water wave: *varies*

wave on string: depends on...

1. Tension on string T [N]

2. mass per length μ [kg/m]

$$v = \sqrt{\frac{T}{\mu}}$$

Waves on a String

