Traveling sinusoidal wave

Consider an electromagnetic wave given by the following electric field:

$$E(x,t) = E_0 \sin\left(2\text{®}\,\frac{x}{\text{a}} - 2\text{®}\,\frac{t}{T} \right)$$

$$= E_0 \sin\left(2\text{®}\,\frac{x - vt}{\text{a}} \right)$$

The wave is moving in …

(A) positive x-direction

(B) negative x-direction

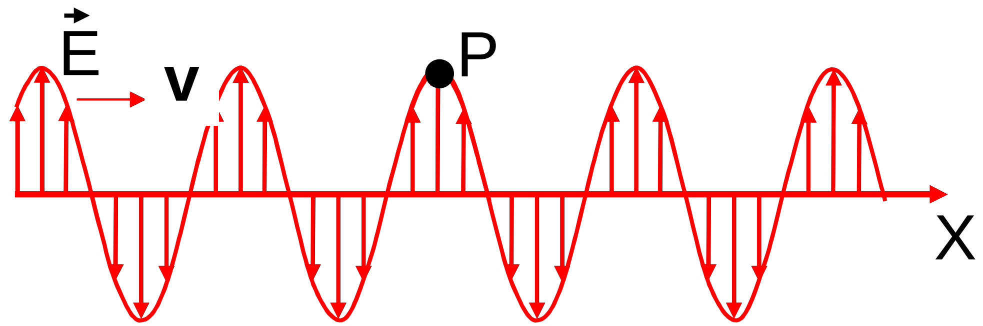
Derivatives of sinusoidal functions

What is $\dfrac{d}{dx}\sin(kx)$?

(A) $\sin(kx)$ (B) $\cos(kx)$ (C) $k\sin(kx)$

(D) $k\cos(kx)$ (E) $-k\cos(kx)$

What happens to the electric field vector at point P when the wave has traveled to the right *a little bit*?



(A) increases

(B) decreases

(C) remains the same

Electromagnetic waves I

- Coupled oscillating electric and magnetic field

- Function of position and time

$$E(x,t) = E_0 \sin(kx \pm \mu t) \qquad E(x,t) = E_0 \cos(kx \pm \mu t)$$

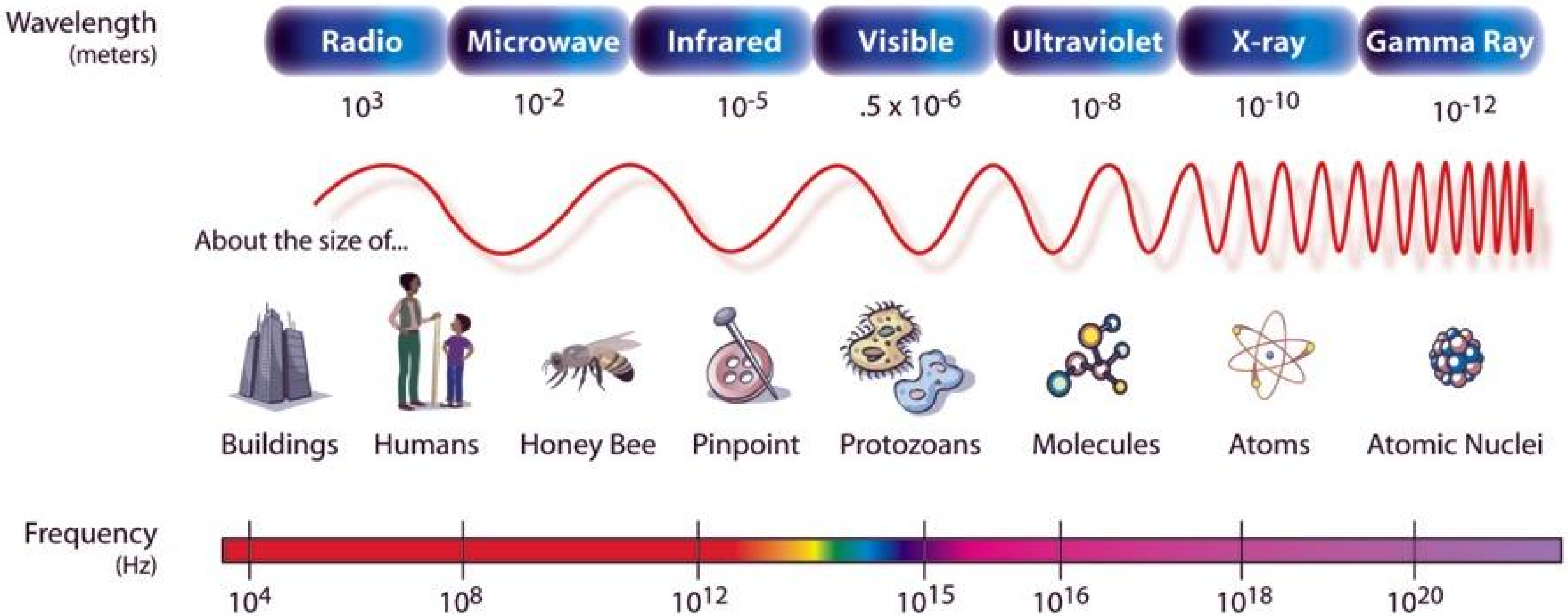
- Wavelength (λ): Distance until wave repeats

- Period (T): Time for one wavelength to pass
  by a given point

- wave number $k = \frac{2®}{a}$; angular frequency $\mu = \frac{2®}{T}$

Electromagnetic waves II

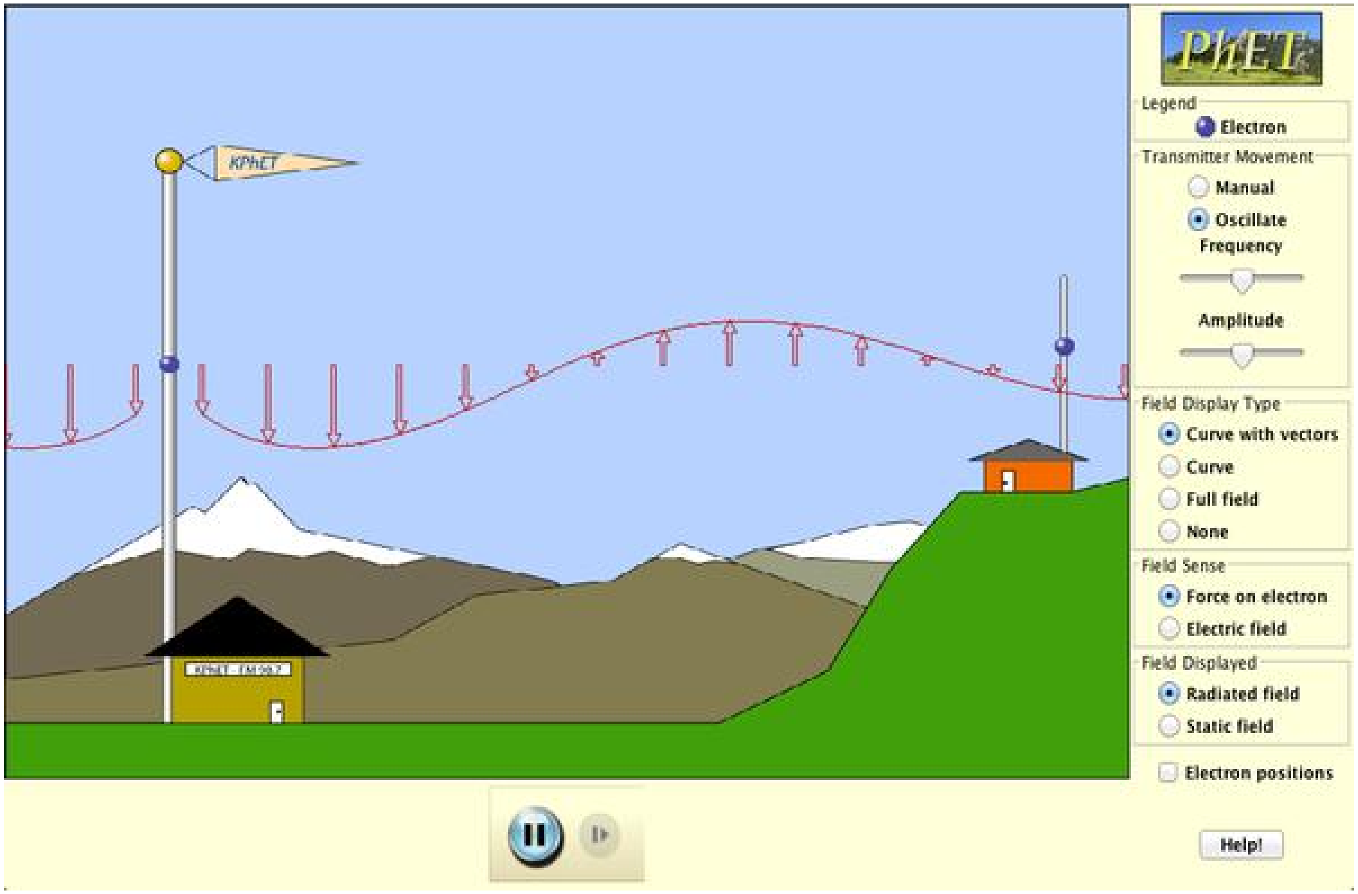
Wavelength: Distance until wave repeats



Frequency: $f = 1/T$ speed: $v = \frac{a}{T} = a f$

Speed is always $v = c = 3x10^8$ m/s in vacuum

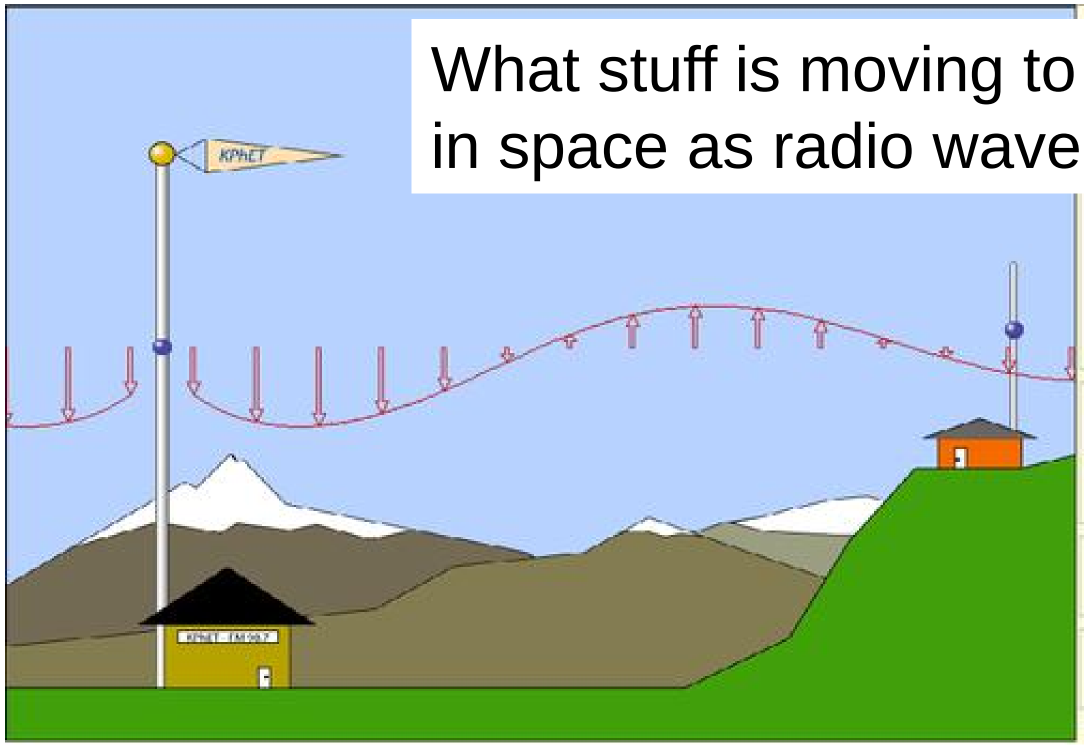
PhET simulations



http://phet.colorado.edu/en/simulation/legacy/radio-waves

Radio wave

What stuff is moving to the right
in space as radio wave propagates?



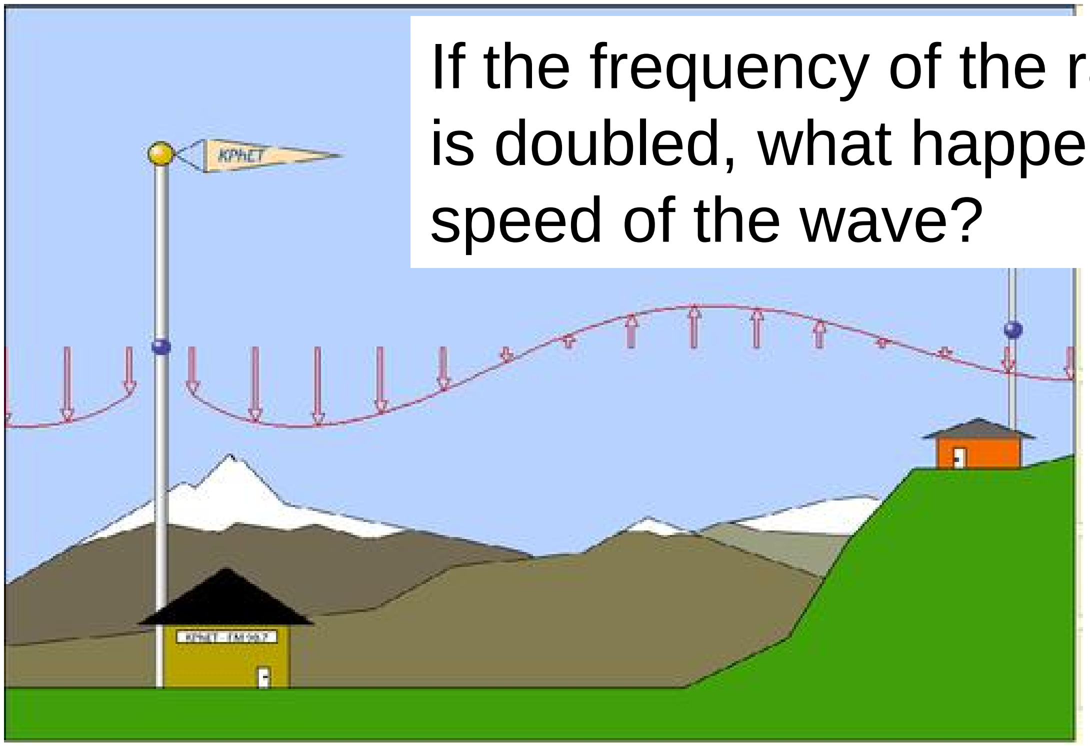
(A)Disturbance in electric field

(B) Electrons

(C) Air molecules

(D) Nothing

Radio wave



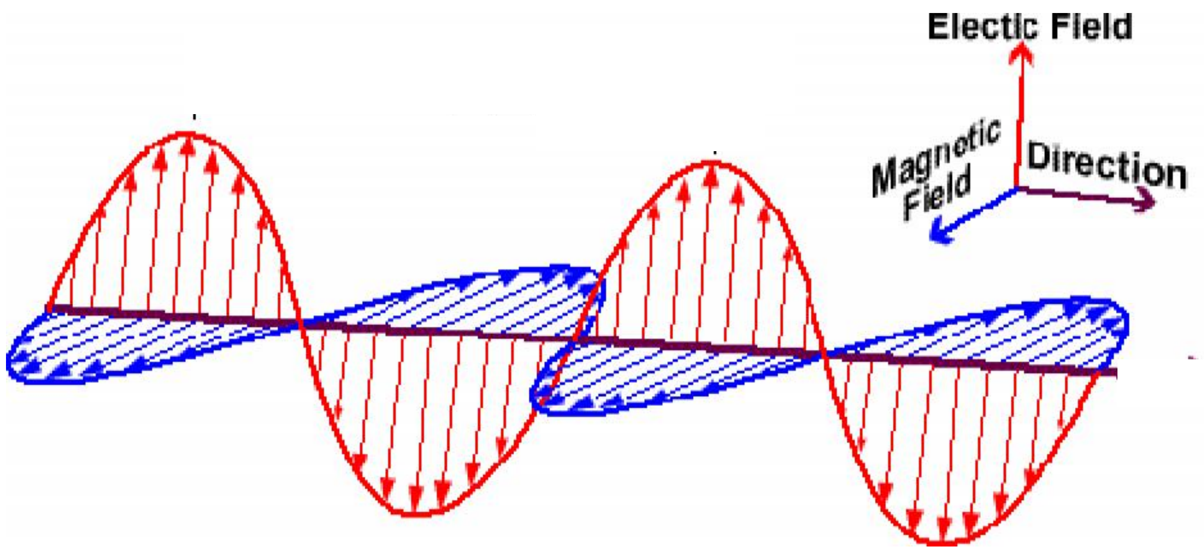
If the frequency of the radio wave is doubled, what happens to the speed of the wave?

(A) it doubles

(B) it halves

(C) it stays the same

Electromagnetic waves III



- E and B fields are perpendicular to each other and to the direction of propagation (EM waves are transverse)
- E and B field oscillate "in phase"
- B(peak) = E(peak)/c

Electromagnetic waves IV

- EM waves carry (transport) energy

$$W = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{1}{\mu_0} B^2\right) = \varepsilon_0 E^2$$

- Power (*P*) = Rate at which wave energy transfers energy

- Intensity $I = \frac{P}{A}$ A: area

Interference patterns