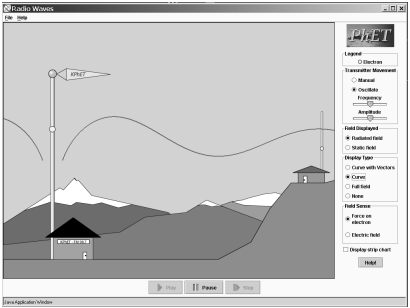


## 3.1.1 Light as a wave

### **Remember:**

- Classical Statistics Lab (Part I)  
due at the beginning of lecture on  
Friday 2/25
- Classical Statistics Lab (Part II)  
due at the beginning of lecture  
on Friday 3/4



At what speed do radio waves move?

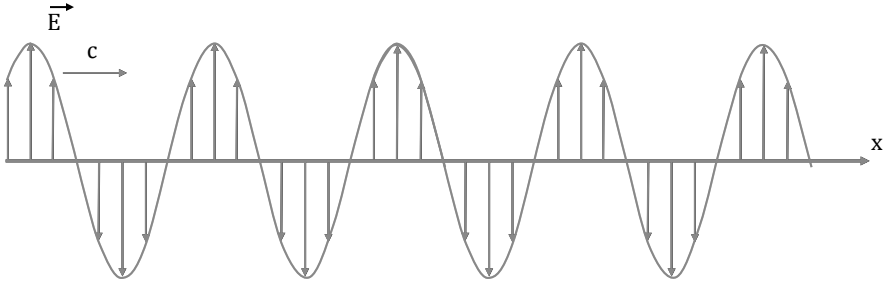
- A. The speed of sound
- B. The speed of light
- C. At different speeds depending on the frequency
- D. At different speeds depending on the amplitude

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## Light as a wave

Snap shot of E-field in time:

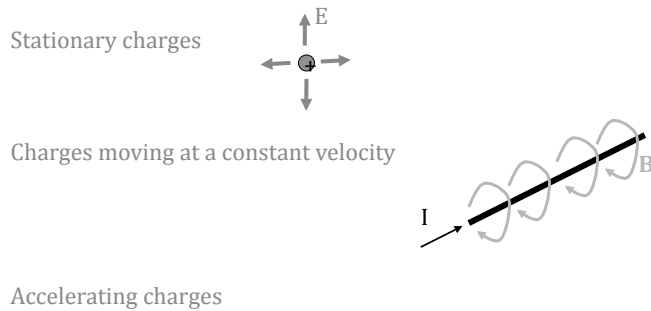
At  $t=0$       A little later in time



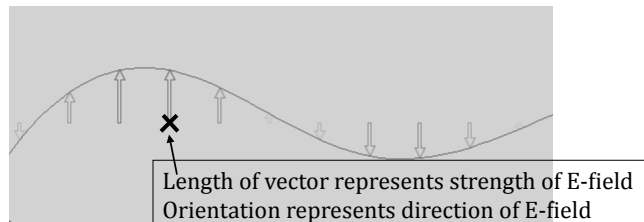
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How do you generate light (electromagnetic radiation)?

- A. Stationary charges
- B. Charges moving at a constant velocity
- C. Accelerating charges**
- D. A, B and C



Snapshot of radio wave in air.

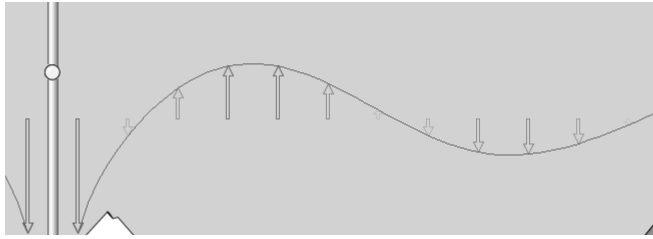


What is physically moving up and down in space as radio wave passes?

- A. electric field
- B. electrons
- C. air molecules
- D. nothing

D. answer is nothing.  
Electric field strength  
*increases and decreases*  
– doesn't move up and down.

Snapshot of radio wave in air.

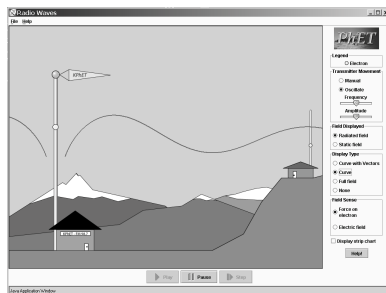


What is physically moving to the right in space as radio wave propagates?

- A. electric field
- B. electrons
- C. air molecules
- D. nothing

A. disturbance in the electric field.

EM radiation often represented by a sinusoidal curve.



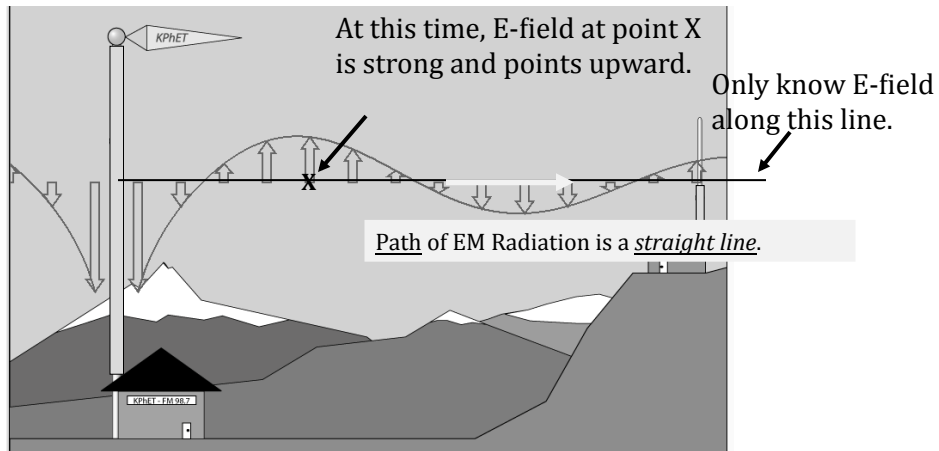
OR



What does the curve tell you?

- A. The spatial extent of the E-field. At the peaks and troughs the E-field is covering a larger extent in space
- B. The E-field's direction and strength along the center line of the curve
- C. The path of the light travels
- D. none of these.

B. The E-field's direction and strength along the center line of the curve



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How much time will pass before this peak reaches antenna?  
( $c$ =speed of light)

A.  $cd$   
B.  $c/d$   
C.  $d/c$   
D. none of the above

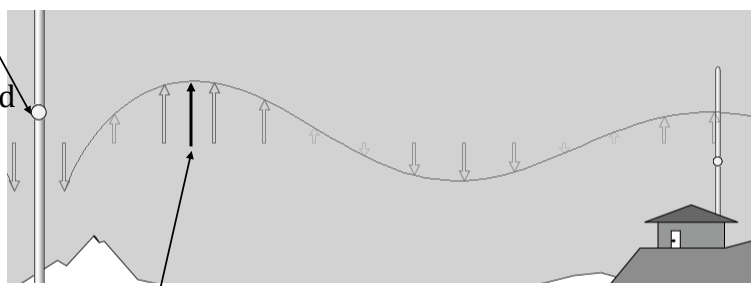
Distance = velocity \* time  
Time = distance/velocity =  $d/c$

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Electron oscillates with period of  $\tau$



How far away will the peak E-field be before the next peak is generated?

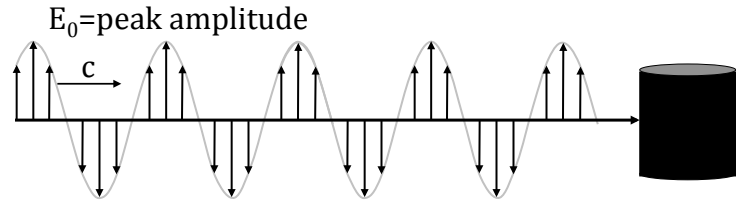
A.  $c\tau$   
 B.  $c/\tau$   
 C.  $c\tau/c$   
 D. none of the above

A  
 Distance = velocity \* time  
 Distance =  $c\tau = c/f = \lambda$

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## Electromagnetic waves carry energy

$E_0 = \text{peak amplitude}$



$E(x,t) = E_0 \sin(kx - \omega t)$

Light shines on black tank full of water.  
 How much energy is absorbed?

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#1

#2

#3

Which barrel will heat up the fastest?

A. 2>1>3      B. 1>2>3

C. 1=2>3      D. 1=3>2

$E_{1\max} = E_{2\max} > E_{3\max}$

Answer is c.

Intensity = power/area  $\propto E_{\max}^2$

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### Wave equation

In 3-D:

$$\nabla^2 E = \frac{1}{c^2} \frac{\partial^2 E}{\partial t^2}$$

In 1-D:  $\frac{\partial^2 E}{\partial x^2} = \frac{1}{c^2} \frac{\partial^2 E}{\partial t^2}$

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## Two slit interference

The diagram illustrates the process of two-slit interference. On the left, a plane wave with wavelength  $\lambda$  is incident on a double slit. The top view shows the waves spreading out from each slit. On the right, a viewing screen shows the resulting interference pattern with bright and dark fringes. The central maximum is labeled  $m=0$ , and the other maxima are labeled  $m=1, 2, 3, 4$  on both sides.

1. A plane wave is incident on the double slit.
2. Waves spread out behind each slit.
3. The waves interfere in the region where they overlap.
4. Bright fringes occur where the antinodal lines intersect the viewing screen.

Top view of the double slit

$m = 3$   
 $m = 2$   
 $m = 1$   
 $m = 0$   
 $m = 1$   
 $m = 2$   
 $m = 3$   
 $m = 4$

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## Constructive interference:

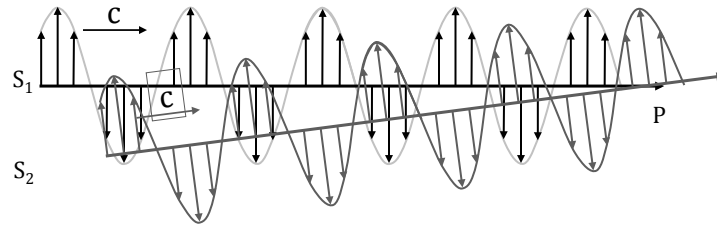
The diagram shows two sources,  $S_1$  and  $S_2$ , emitting waves that travel to a point  $P$ . The path difference between the two waves is labeled  $c$ . The waves are shown in phase at  $P$ , indicating constructive interference.

$$S_1P - S_2P = n \lambda$$

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Destructive interference:



$$S_1P - S_2P = (n + \frac{1}{2}) \lambda$$