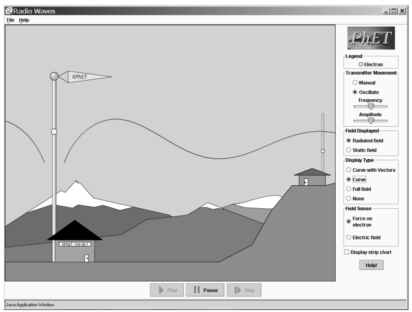
3.1.1 Light as a wave

Remember:

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



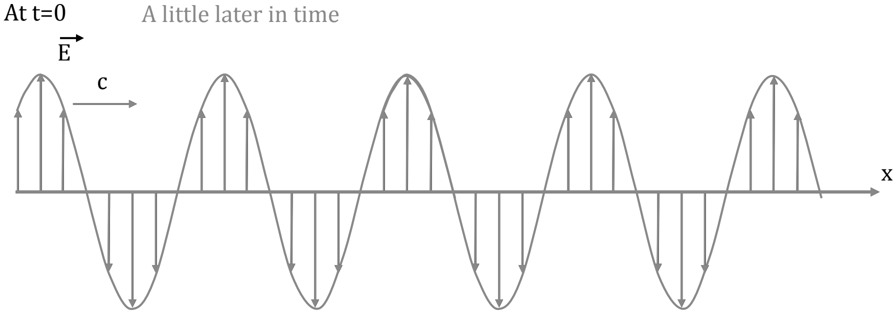
At what speed do radio waves move?

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

Light as a wave

Snap shot of E-field in time:

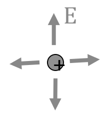
At t=0 A little later in time



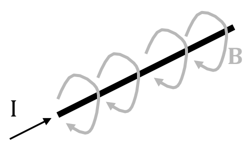
How do you generate light (electromagnetic radiation)?

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

Stationary charges

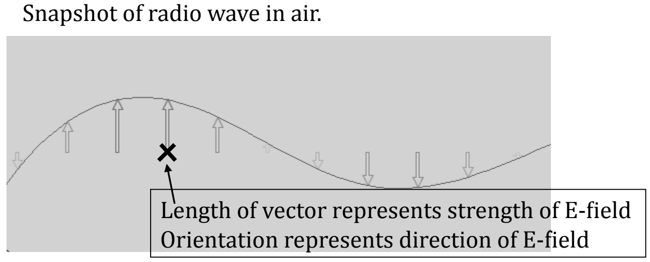


Charges moving at a constant velocity



Accelerating charges

Snapshot of radio wave in air.

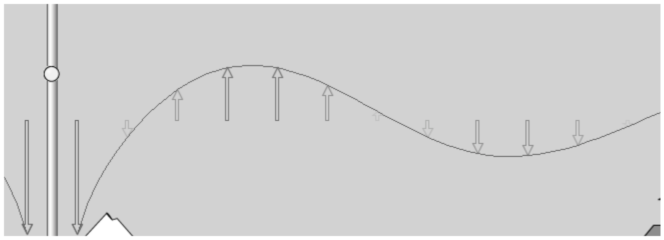


What is physically moving up and down in space as radio wave passes?

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.

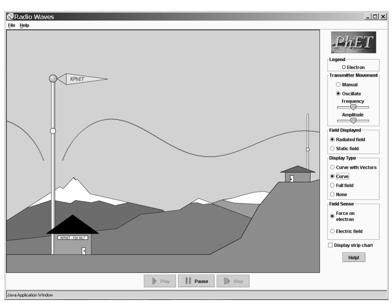


What is physically moving to the right in space as radio wave propagates?

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

A. disturbance in the electric field.

EM radiation often represented by a sinusoidal curve.



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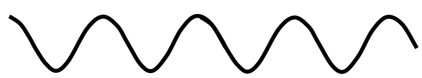
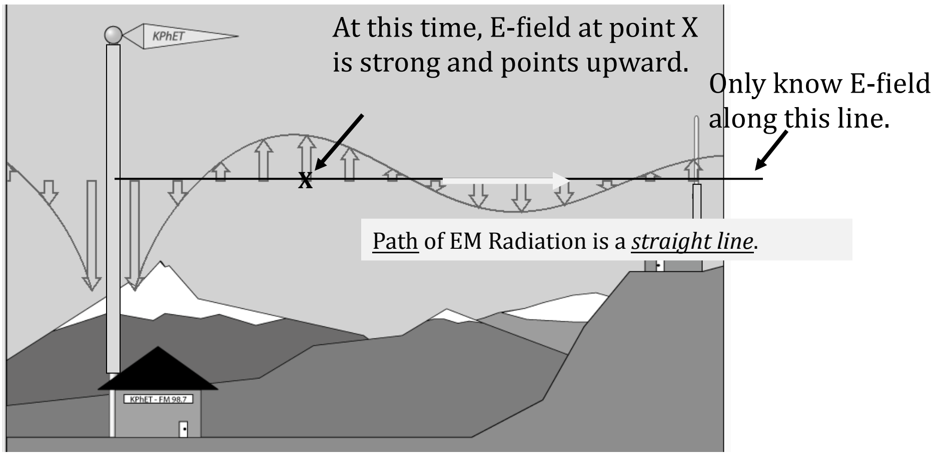
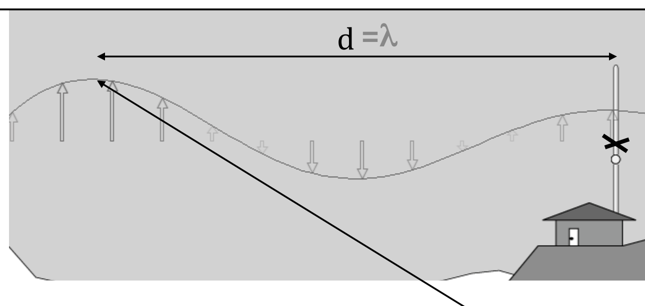


What does the curve tell you?

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



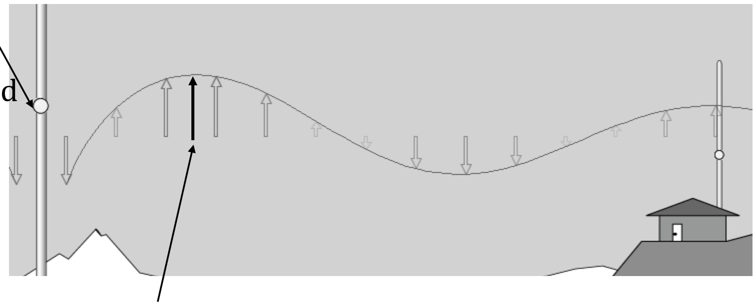


How much time will pass before this peak reaches antenna? (c=speed of light)

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

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

Electron oscillates with period of τ



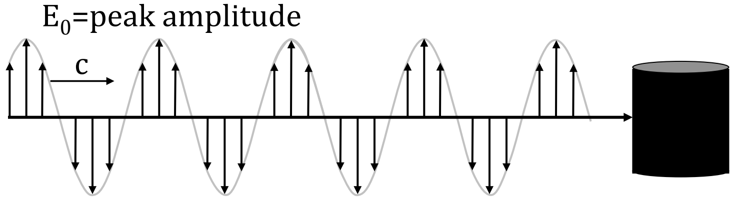
How far away will the peak E-field be before the next peak is generated?

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

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

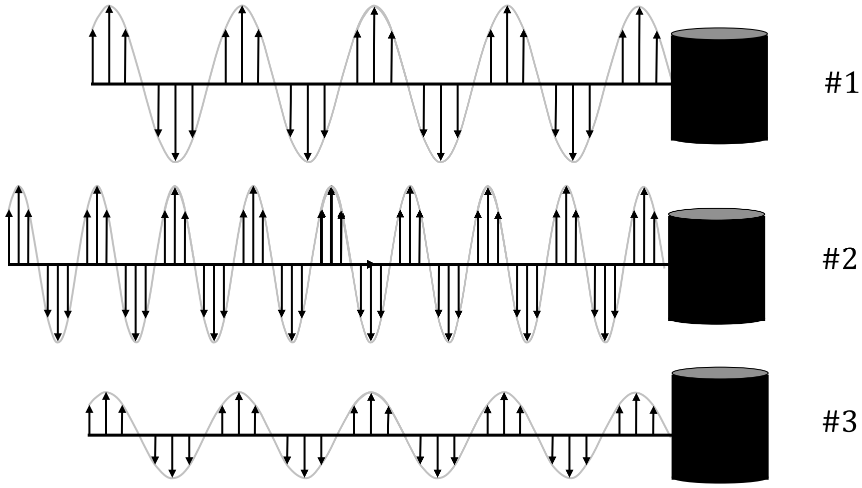
Electromagnetic waves carry energy

E_0=peak amplitude



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

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



Which barrel will heat up the fastest?

A. 2>1>3 B. 1>2>3

C. 1=2>3 D. 1=3>2

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

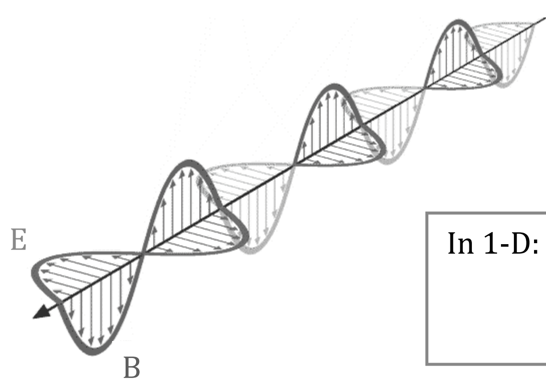
Answer is c.

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

Wave equation

In 3-D:

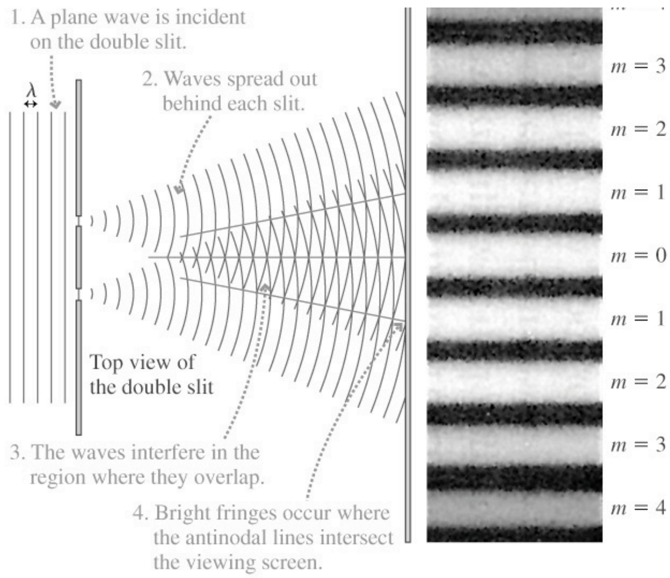
$$\nabla^2 E = \frac{1}{c^2}\frac{\partial^2 E}{\partial t^2}$$



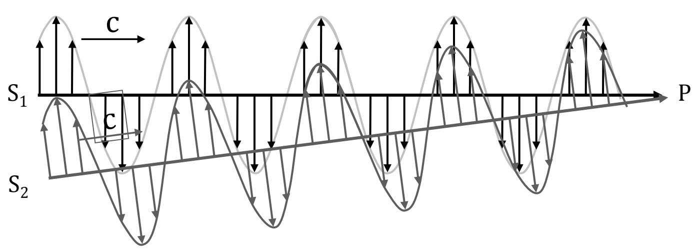
In 1-D:

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

Two slide interference

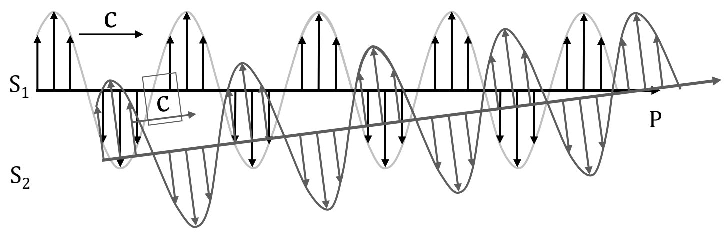


Constructive interference:



$$S_1P - S_2P = n\lambda$$

Destructive interference:



$$S_1P - S_2P = (n+½)\lambda$$