

Arvind Borde / PHY 12, Week 7: Electromagnetic Radiation

What do you know so far?

(1) What in the name of electricity creates electric fields? _____

(2) What in the name of magnetism creates magnetic fields? _____

Next, the connection between the two.

1

(3) What in the name of magnetism produces electric fields? _____

(4) What in the name of electricity produces magnetic fields? _____

2

James Clerk Maxwell thought so.

In 1888 he produced a beautiful synthesis of all the previous work on the subject of electricity and magnetism, under four laws that bear his name.

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Maxwell's Laws

1. _____

2. _____

3. _____

4. _____

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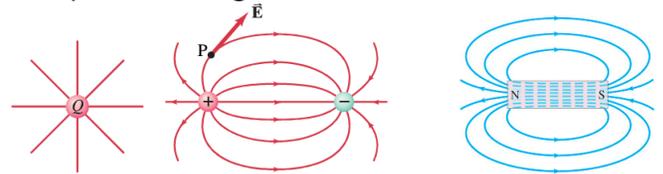
Three-and-a-half of Maxwell's Laws were a summary of the previous discoveries of others.

But his proposal that magnetic fields would be produced by changing electric fields was new.

Maxwell was motivated by the apparent symmetry between electricity and magnetism.

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There's a deep truth hidden in Maxwell's Laws. One way to produce electric or magnetic fields is through _____: charges produce electric fields, poles produce magnetic fields.



6 (As in gravitation, masses produce gravitational effects.)

ADDITIONAL NOTES

With sources, something concrete (a charge, a magnet, a mass) produces an abstraction, a field.

(5) Why do we think this abstraction is “really there”?

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(6) Do Maxwell’s Laws say there’s another way to produce electric and magnetic fields? =====

And, as with fields caused by sources, we can equally well measure the fields caused by fields.

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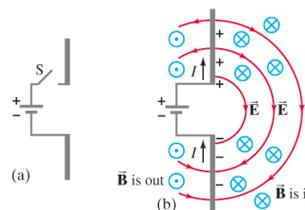
What would a field caused by a field look like?

It can be a self-sustaining process.

Let’s go to an animation.

Still, you cling stubbornly to a “cause”?

Here’s a scenario, with cause:

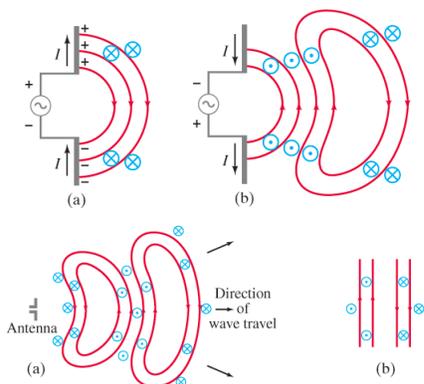


A DC current creates a constant magnetic field

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DC → AC:



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So, these oscillating EM fields can persist in empty space. Do they just hang out, or do they move?

They move, with a speed given by

$$k = 9 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2, \text{ and } \epsilon_0 = 1 / 4\pi k$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m} / \text{A}$$

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ADDITIONAL NOTES

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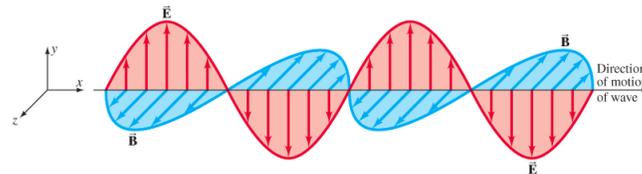
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(7) Calculate $1/\sqrt{\epsilon_0\mu_0}$

(8) Do you recognize that value?

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Visible light is part of the “electromagnetic spectrum.”



Magnitudes decrease as $1/r$.

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What is Light?

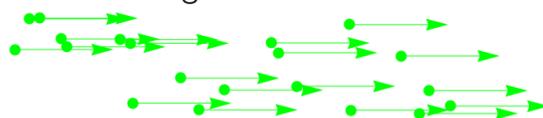
When people say “light” they usually mean visible light.

But it's one form of a larger phenomenon called _____ . We'll use “light” to cover the whole spectrum.

Light has a dual nature: particle and wave.

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Light as a Particle



The individual particles (“packets of energy”) are called ...

(9) What? _____

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Light as a Wave

(10) What's a wave? _____

The two key attributes of waves are:

- ▷ How long they are (_____, λ), and
- ▷ How frequently they pass (_____, ν).

The speed of a wave, c , is related to these two by

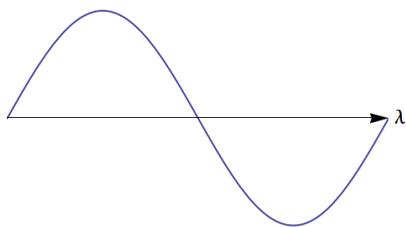
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(11) If two waves (Wave A and Wave B) have the same speed, but Wave A has twice the wavelength of Wave B, how are their frequencies related?

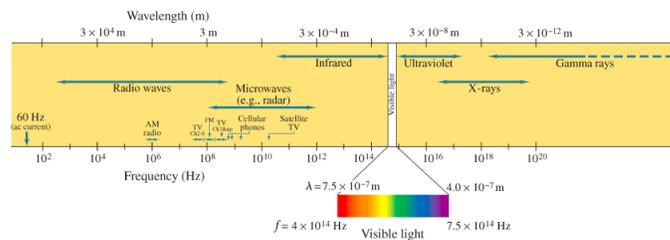
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ADDITIONAL NOTES

Visualizing wavelength

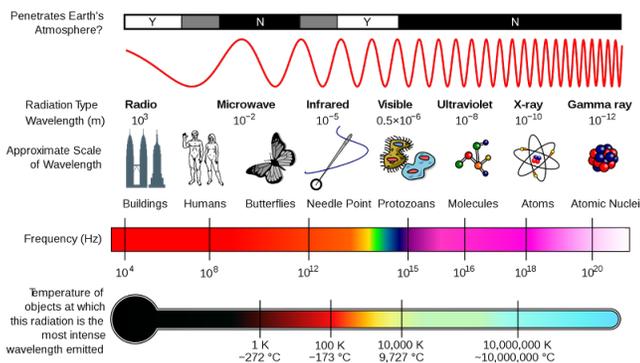


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Different forms of electromagnetic radiation have different wavelengths:

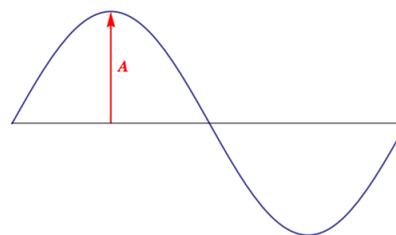
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ELECTROMAGNETIC SPECTRUM: http://www.thenanoage.com/images/EM_Spectrum_Properties.png

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Wave Amplitude



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The Medium

Water carries water waves, air carries sound waves.

(12) What carries EM waves? _____

Hertz confirmed the existence of EM waves in 1887.

He created waves by rapidly changing charges, then measured the induced emf as the waves passed a loop.

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ADDITIONAL NOTES

