FREQUENTLY ASKED QUESTIONS

May 13, 2003

Content Questions

I'm still a bit confused about the equation for a plane wave.

A plane wave is a wave that wiggles up and down in some direction, and moves along over time in the perpendicular direction.. For instance consider $A_y = A\cos(kz - wt)$. If you take a snapshot in time, and plot A_y versus z, you get a wiggling shape in y, as a function of z. If you look at how this shape changes in time, you see that the wave shape *moves forward* along the z axis.

It's called a "plane wave" because the pattern in the plane perpendicular to the direction of motion (in this case the yx plane) is constant as the wave moves along, sort of the way a wave carrying a surfer looks the same as the wave moves forward.

How do you tell what direction a plane wave is moving in?

You can figure it out just from the form of the plane wave given. For instance consider $E_0 \cos(kz + \omega t)$.

This equation shows that the wiggling is a function z, so it must be either in $+z$ or $-z$. The rule is that if the kz and ωt parts in the argument of cosine have opposite signs (either $kz - \omega t$ or $\omega t - kz$), then the wave is traveling in the $+z$ direction (to see these are equivalent: remember $\cos x = \cos(-x)$.)

On the other hand, if kz and ωt have the *same* sign, (argument of cosine is $kz + \omega t$) then the wave is in the $-z$ dir. To see this: take the case of the wave

$E_0 \cos(kx - wt) = E_0 \cos(2\pi x/\lambda - \omega t) = E_0 \cos(\frac{2\pi}{\lambda}(x - vt))$

using that $\omega = 2\pi v/\lambda$.

Now suppose you are riding along on the crest of the wave to the right ($+x$ dir, increasing x). The argument of the cosine function must remain the same as t increases, so that you always sit at the same amplitude as you move along with speed v. As t increases, x increases as vt; but the argument of the cosine must be constant, so it must have $x - vt$ in it. So the argument of cosine if you are moving to the right with speed v is $\frac{2\pi}{\lambda}(x - vt)$. Similarly, if you are moving to the left, x decreases as $-vt$, so to make the argument of the cosine constant, it must have $x + vt$.

When figuring out what the reflected wave looks like for MW, how do you know what the non-reflecting wave looks like in the space between the transmitter and the reflector?

The transmitter is creating em waves in *both directions*, towards the receiver and towards the reflector. So the pattern towards the reflector should be symmetric with the pattern towards the receiver.

How do the transmitter and receiver relate to the MW experiment?

Although there's a lot of stuff folded in to MW (almost all the ideas in this course are connected to it somehow!), the really basic idea is to make a transmitter that creates em waves (of microwave frequency), and detect them with a receiver. Both transmitter and receiver are antennae. The transmitter is the antenna connected to the EB apparatus, and it creates em waves via electrons that zing back and forth in the antenna whenever a spark gives them a kick. The receiver is the other antenna you make, connected to your amplifier. Electrons in this receiver get pushed around by the electric fields of the microwave, and this small current gets amplified and you see its effect on the MMM.

This is the basic idea behind radio, TV, cell phones etc, too!

How can we use our microwave experiment to heat food?

Hmm, well although it might be convenient to finish your lab and make popcorn at the same time, I don't think your setup has enough power to do this. Actually, microwave ovens for heating food make use of standing waves in your oven! (That's the reason you may sometimes find cold spots in your microwave-heated food: there are nodes in the standing waves). In addition, they make use of resonance: the em wave frequency used in a microwave is tuned to be a frequency that water absorbs a lot of energy at. Food is made mostly of water, so it heats efficiently. (The reason that Bad Things Happen when you put tin foil or other metal in the microwave is that metal conducts well, and electrons get driven around by the microwaves a little too enthusiastically).

A link on how microwave ovens work:
http://home.howstuffworks.com/microwave.htm

Aren't standing waves when there's destructive interference? What are standing waves exactly?

Actually there is both destructive and constructive interference happening in standing wave at different times (in class I drew a point in time for constructive interference). The overall pattern when the reflectors are in the right configuration is one where the positive and negative parts of the wave a "flip-flopping" back and forth in time, and there's a "node" in the center that does not move. It's easiest to imagine in the mechanical analogy of a jump rope connected to the wall and wiggled up and down in such a way that a stable pattern is formed. This kind of wave is called a standing wave because it does not move forward or backward like a plane wave.

What do we need to understand for the MW write-up?

For problem 2, you need to understand about plane waves, and the specific case of EM waves for parts a and b. For part c, you need to understand what happens when a wave is reflected. Parts d and e involve constructive and destructive interference, and the last part involves standing waves.

Tidbits

A limerick by David Morin about the blue sky, from the Physics Limericks Page:

A young child looked up in the sky,
And said, ”It’s so blue, Mom, but why?”
Well, blue scatters more
(There’s this power of 4),
So it rarely comes straight to your eye.

Why does Prof. Roland always wear black, even though he seems like a really happy guy?

I don’t think I can answer that one! I suspect it’s just a fashion statement, but I think you’ll have to ask Prof. Roland himself.

Have a great summer everyone!!