Instructor: Gordon D. Cates
Office: Physics 106a, Phone: (434) 924-4792
email: cates@virginia.edu

Course web site available through COD and Toolkit
or at http://people.virginia.edu/~gdc4k/phys106/spring07

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Announcements

• I will hold office hours this coming Tuesday, April 3rd, at 10:30AM for people who have trouble with the other times. With no homework due, it is a good time to come to shore up your understanding of homework, quiz, or midterm questions that you found confusing.

• Lectures 21-24 have been posted on the web. Other updates are to follow shortly.
Observations about microwave ovens

- Food gets hot but containers usually do not.
- They heat food from the inside out, and food doesn’t “brown.”
- They often heat food very unevenly.
- Frozen foods do not defrost well.
- There can be (sometimes serious) problems when metal is put in a microwave oven.
- The oven can heat through plastic, glass and ceramic containers, but does not heat things through its semi-transparent door.
The wavelength, frequency, and speed of electromagnetic waves

• The speed of electromagnetic waves in a vacuum is always the same: \( c = 3 \times 10^8 \text{ m/s} \)
• The wavelength and frequency are related by a simple equation: \( c = \text{frequency} \times \text{wavelength} \)
The electromagnetic spectrum

The range of wavelengths of electromagnetic waves associated with phenomena that are important to us is huge.
How do microwave ovens heat food?

• Water molecules are “polar”, the hydrogen atoms are charged positively, and the oxygen atoms are charged negatively.
• In an electric field, water molecules can experience a torque that tends to twist them.
• If the electric field oscillates back and forth in its direction, the molecules can be twisted back and forth.
A water molecule reacting to microwaves in real time
How do microwave ovens heat food?

As the electric field oscillates back and forth, the water molecules twist back and forth.

As they bump into each other in a random fashion, the energy in their twisting motion is lost to thermal energy.
Question:

Will microwaves heat liquid water and frozen water with the same efficiency?
Question:

What happens if we put metal in a microwave oven?
Question:
Why might twist ties and other sharp objects be particularly troublesome?
How are the microwaves produced?

It involves a tiny tank circuit that resonates at just the right frequency.

Both the inductor and the capacitor must be very small to resonate at a high enough frequency.

Each resonating element is a small “C-shaped” piece of metal.
Magnetron tubes

The microwaves are actually produced in what are called magnetron tubes.

The tubes contain a resonator with many of the small "C-shaped" elements discussed earlier.
Powering the magnetron with an electron beam

The tubes are excited by an electron beam that originates from a heated “cathode” in the middle.

As the electron beam travels toward the edges of the resonator structure, a magnetic field bends the beam so that it actually contributes to the charge on the capacitors.