HW #4 Due Feb 11 at the ***beginning*** of class.

READING: This week we will be working on Ch. 18, a much easier chapter than Ch. 17. You will be responsible for all the material in sections 18-1 to 18-8, but we will not cover all of this material in class, so you will have to read the book on your own. I don't think you will find the problems too difficult, even for the material we do not talk about in class. You will not be responsible for sections 18-9 or 18-10, but both are interesting, and should be part of the knowledge base of every educated person, so I strongly encourage you to read them.

I noticed that the scores on HW2 were rather low. I would normally expect that the HW component of your course grade would help your grade, I hope you will work hard in the future to try to get all of the problems at least mostly correct. To help your HW grade a little, I have assigned some optional extra credit problems this week. These are not easy problems but you can ask for help if necessary. I will grade them myself.

Please hand in the HW in *three* parts.

Part I:	Ch. 17 Problems #32, 39, 46, 48
	Ch. 18 Questions #10, 12
	Ch. 18 Problems #7, 8, 9
Part II:	Ch. 18 Problems #13,20,28,30,34
	Additional Problems 1, 2, 3
Part III:	Extra Credit Problems #1, 2 (up to 8 pts. extra credit)

<u>Additional Problems</u>

1) A 47 pF capacitor is charged to a voltage of 15 V. The plates of the capacitor each have an area of 7.18 cm^2, and the plates are separated by paper with a dielectric constant of 3.7.

a) How much charge is on each plate?
b) How much energy is stored in the capacitor?
c) What is the distance between the plates, in mm?

2) A typical toaster oven is rated at 1500 W and operates at the normal household voltage of 120 V AC.

a) What is the rms current?
b) What is the peak current?
c) If the oven takes 3 minutes to make a slice of toast, and electrical energy costs 15 cents per kWh, how much does it cost to make a slide of toast?

3) This is a review problem for Gauss's Law and electric potential.

a) A solid metal sphere of radius R has a charge Q. Use Gauss's Law to derive an expression for the electric field outside of the sphere at some distance r measured from the center of the sphere, with r > R. Clearly explain your reasoning.
b) According to your result from a) the field outside the sphere is exactly the same as the field due to a point charge, Q located at the center of the sphere. Use this result to argue that the potential at the surface of the sphere is kQ/R.

c) What are the values for the electric field and potential inside the sphere? Briefly explain.

Extra Credit Problems

1) This is a review problem for Ch. 17, and touches upon a topic that we did not have time to talk about in class.

Imagine two metal spheres connected by a thin conducting wire. One sphere has a radius of 9 cm and the other has a radius of 1 cm. A charge +500 nC is transferred to the spheres and distributes itself amongst the spheres. We can assume that the charge on each sphere is uniformly distributed over the surface of the sphere, but we should not assume that the total charge is evenly distributed between the two spheres. Since the spheres are metal and connected by a wire, both spheres must be at the same potential (if they were not, electrons would flow until the potentials were the same).

a) Determine the charge on each sphere. Hint: Use your result from additional problem #3 and the fact that the potentials must be the same.
b) Determine the electric field at the surface of each charge.
c) What is the ratio of the field at the surface of the small sphere to the field at the surface of the large sphere?

With these results you can understand how a lightning rod works. Looking at your numbers you should see that the field at the surface of the small sphere is sufficient to cause an electrical breakdown of the air (> 3,000,000 V/m), while the field at the surface of the large sphere is not. The small sphere corresponds to a "pointy" object (lightning rod), whereas the large sphere corresponds to a flat object (roof top), and both are at the same potential (ground potential).

Many people think that a lightning rod attracts a lightning bolt. This is only partially correct. Actually, in many cases a lightning rod discharges a cloud thus preventing a big strike. When a charged cloud passes over a lightning rod, the field becomes strong enough in the vicinity of the rod to ionize the air and the cloud discharges through the lightning rod and its wire to the earth gradually, rather than in an abrupt bolt of lightning. If a big bolt does come down, then the bolt will be more likely to go to the pointy lightning rod than to the flat roof surface of the building being protected.

This is also why it is bad to be on a golf course during a thunderstorm. When you swing your club overhead it becomes a lightning rod that can discharge the cloud through you. If you were instead to lie flat on the ground (preferably in a gulley), the cloud may not discharge at all, or if it does, there would me no more reason to discharge through you than through any other place on the ground.

Finally, cows are often electrocuted during a storm because they tend to huddle under a tree, which acts like a lightning rod. Being directly under the tree they may be exposed to a dangerous charge flow.

2) Two small charged objects are separated by 10 cm. One has a mass of 1 g and a charge of -1 μC. The other has a mass of 2 g and a charge of -2 μC. They are released from rest and fly apart. What is the speed of each mass when they are very far apart? Hint: Conservation of energy is not the only conservation law at work in this problem.