Homework 20 for October 1 2008
Due 8AM on October 2 2008
Physics 221 with Professor Jeff Terry

1. A parallel-plate capacitor is charged by and then disconnected from a battery. How does the stored energy change when the plate separation doubles?

Use $U = \frac{1}{2}\frac{Q^2}{C}$ and $C = \frac{\epsilon_0 A}{d}$.

If $d_2 = 2d_1$, $C_2 = \frac{1}{2}C_1$. Therefore, the **stored energy doubles**.

2. Two capacitors in parallel have an equivalent total capacitance of 9.00 pF. When they are connected in series they have an equivalent total capacitance of 2.00 pF. What is the capacitance of each capacitor?

$C_p = C_1 + C_2$ $\qquad \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$

Substitute $C_2 = C_p - C_1$ $\qquad \frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_p - C_1} = \frac{C_p - C_1 + C_1}{C_1(C_p - C_1)}$.

Simplifying, $\qquad C_1^2 - C_1 C_p + C_p C_s = 0$.

$$C_1 = \frac{C_p \pm \sqrt{C_p^2 - 4C_pC_s}}{2} = \frac{1}{2}C_p \pm \sqrt{\frac{1}{4}C_p^2 - C_pC_s}$$

We choose arbitrarily the + sign. (This choice can be arbitrary, since with the case of the minus sign, we would get the same two answers with their names interchanged.)

$$C_1 = \frac{1}{2}C_p + \sqrt{\frac{1}{4}C_p^2 - C_pC_s} = \frac{1}{2}(9.00\text{ pF}) + \sqrt{\frac{1}{4}(9.00\text{ pF})^2 - (9.00\text{ pF})(2.00\text{ pF})} = \boxed{6.00\text{ pF}}$$

$$C_2 = C_p - C_1 = \frac{1}{2}C_p - \sqrt{\frac{1}{4}C_p^2 - C_pC_s} = \frac{1}{2}(9.00\text{ pF}) - 1.50\text{ pF} = \boxed{3.00\text{ pF}}$$