Homework 16 for September 24 2008
Due 8AM on September 25 2008
Physics 221 with Professor Jeff Terry

1. A charge +q is at the origin and a charge -2q is at x=2.00m on the x-axis. For what finite value(s) of x is the E field zero, and for what value(s) of x is the electric potential zero?

$$E_x = \frac{kq_1}{x^2} + \frac{kq_2}{(x-2.00m)^2} = 0$$

$$= \frac{+kq}{x^2} + \frac{-2kq}{(x-2.00m)^2} = 0$$

$$= \frac{1}{x^2} + \frac{-2}{(x-2.00m)^2} = 0$$

$$x^2 + 4.00x - 4.00 = 0$$

$$x = \frac{-4.00 \pm \sqrt{32.0}}{2}$$

$$x = -4.83m : x \neq 0.82m$$

We eliminated the positive value because we know the electric field can not be zero between a positive and negative charge (assuming there is no charge elsewhere). If you doubt this, ask yourself how two positive fields pointing the same direction could ever add to zero.

$$V = \frac{kq_1}{x} + \frac{kq_2}{2.00-x} = 0 = \frac{1}{x} + \frac{-2}{2.00-x}$$

$$x > 2.00m$$

$$\frac{1}{x} + \frac{-2}{x-2} = 0 \therefore x = -2.00m < 2.00m$$

$$2.00m > x > 0$$

$$\frac{qk}{x} + \frac{-2qk}{2.00-x} = 0 = \frac{1}{x} + \frac{-2}{2.00-x}$$

$$2.00 = 3x \therefore x = \frac{2.00}{3}m \approx 0.67m$$

$$x < 0$$

$$\frac{1}{-x} + \frac{-2}{-x+2.00} = 0 \therefore 2.00 = -x \therefore x = -2.00m$$

So we have +0.67 m and -2.00m

2. How much work is required to assemble four identical point charges of magnitude Q at the corners of a square of side s?

We bring the charges in one at a time. The first one requires no work because there is no electric force assembled to repel it. The way to read the subscripts is that U_{12} is the energy stored when moving charge 2 toward charge 1.

$$U = U_1 + U_2 + U_3 + U_4 = 0 + U_{12} + U_{13} + U_{23} + U_{14} + U_{24} + U_{34}$$

$$= 0 + \frac{kQ^2}{s} + \frac{kQ^2}{s}\left(\frac{1}{\sqrt{2}} + 1\right) + \frac{kQ^2}{s}\left(1 + \frac{1}{\sqrt{2}} + 1\right) = \frac{kQ^2}{s}\left(4 + \frac{2}{\sqrt{2}}\right)$$

$$\approx 5.41\frac{kQ^2}{s}$$