**Physics 221**
**Group Project**
**Force, Electric Field, Potential Energy and Potential**

Names: _____

1. A charge of -5.2 nC is at -3.00 m on the $x$-axis. A second charge of 2.60 nC is placed at 3.00 m on the $x$-axis. A 1.0 nC charge is placed at the origin.
    a. Find the force on the charge at the origin.
    b. Find the electric field on the charge at the origin.
    c. Find the electric potential at the origin if the 1.0 nC charge is not present.
    d. Find the electric potential energy of the charge at the origin.

2. In the movie *Back to the Future*, Doc tells Marty that, to power his automotive time machine, he needs at least 1.2 gigawatts ($1.2 \times 10^9$ W) and that he can obtain this from a stroke of lightning. Suppose that a certain lightning stroke lasts 0.20 s and transfers 20 C of charge across a potential difference of $5.0 \times 10^7$ V.
    a. How much energy is delivered, and what is the power of the stroke?
    b. If the time machine uses energy at the rate of 1.2 gigawatts, how long will the energy obtained from the lightning last?
    c. The time machine uses a so-called "flux" capacitor. Assuming that it has characteristics similar to an ordinary capacitor, with a dielectric constant of 100 and a dielectric strength of $1.0 \times 10^8$ V/m, find the minimum volume it can have to store the energy from the lightning stroke. Energy density of a capacitor is $PE/m^3 = \frac{1}{2}\, \kappa \varepsilon_0 E^2$
    d. A typical automobile battery stores about $10^6$ J in a volume of $10^{-2}$ $m^3$. How large would an automobile battery have to be to store the energy from the lightning?