## Physics 111

## Fall 2007

## Electrostatic Forces and the Electric Field

1. Two point charges, $5 \mu \mathrm{C}$ and $-8 \mu \mathrm{C}$ are 1.2 m apart. Where should a third charge, equal to $5 \mu \mathrm{C}$, be placed to make the electric field at the mid-point between the first two charges equal to zero?
2. The electric field inside biological membranes is extremely high, roughly $1 \times 10^{7}$ $\mathrm{N} / \mathrm{m}$. If this electric field generated the only force on a sodium ion, what would its acceleration be?
3. Find the force on a $5 \mu \mathrm{C}$ point charge located at a vertex on an equilateral triangle of 0.5 m sides if $10 \mu \mathrm{C}$ point charges are located at the other two vertices.
4. How close must two electrons be if the electric force between them is equal to the weight of either at the Earth's surface?
5. A proton ( $m=1.67 \times 10^{-27} \mathrm{~kg}$ ) is suspended at rest in a uniform electric field $\overrightarrow{\mathbf{E}}$. Take into account gravity at the Earth's surface, and determine $\overrightarrow{\mathbf{E}}$.
6. In a simple model of the hydrogen atom, the electron revolves in a circular orbit around the proton with a speed of $1.1 \times 10^{6} \mathrm{~m} / \mathrm{s}$. Determine the radius of the electron's orbit. [Hint: what do you recall about circular motion?]
7. A small lead sphere is encased in insulating plastic and suspended vertically from an ideal spring ( $k=126 \mathrm{~N} / \mathrm{m}$ ) above a lab table, shown below. The total mass of the coated sphere is 0.800 kg , and its center lies 15.0 cm above the tabletop when in equilibrium. The sphere is pulled down 5.00 cm below equilibrium, an electric charge $Q=-3.00 \times 10^{-6} \mathrm{C}$ is deposited on it and then it is released. Using what you know about harmonic oscillation, write an expression for the electric field strength as a function of time that would be measured at the point on the tabletop (P) directly below the sphere.

8. Given the two charges shown below, at what position(s) $x$ is the electric field zero? Is the field zero at any other points, not on the $x$ axis?

9. Two point charges, $+Q$ and $-Q$ of mass $m$, are placed on the ends of a massless rod of length $L$, which is fixed to a table by a pin through its center. If the apparatus is then subjected to a uniform electric field $E$ parallel to the table and perpendicular to the rod, find the net torque on the system of rod plus charges.
10. Four equal positive point charges, each of charge $8.0 \mu \mathrm{C}$, are at the corners of a square of side 9.2 cm . What charge should be placed at the center of the square so that all charges are at equilibrium? Is this a stable or unstable equilibrium in the plane?
11. A large electroscope is made with "leaves" that are $78-\mathrm{cm}$-long wires with tiny $24-\mathrm{g}$ spheres at the ends. When charged, nearly all the charge resides on the spheres. If the wires each make a $30^{\circ}$ angle with the vertical as shown below, what total charge $Q$ must have been applied to the electroscope? Ignore the mass of the wires.

12. Suppose that electrical attraction, rather than gravity, were responsible for holding the Moon in orbit around the Earth. If equal and opposite charges $Q$ were placed on the Earth and the Moon, what should be the value of $Q$ to maintain the present orbit? Use these data: mass of Earth $=5.98 \times 10^{24} \mathrm{~kg}$, mass of Moon $=7.35 \times 10^{22} \mathrm{~kg}$, radius of
orbit $=3.84 \times 10^{8} \mathrm{~m}$. Treat the Earth and Moon as point particles.
