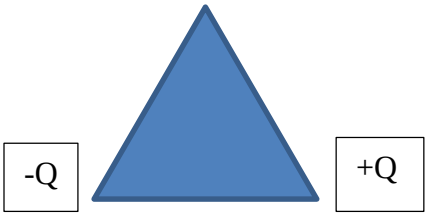
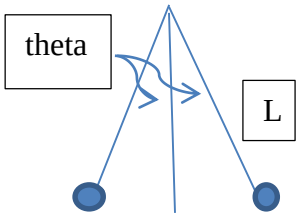
Charge, Coulomb's Law and the Electric Field problem set 1

1. Three charges are arranged in an equilateral triangle of side a. The base charges are $+Q$ and $-Q$. What is the force on the charge $+q$ at the top of the triangle?



2. Two point particles, each of mass m and charge q, are susupended from a common point by threads of length L. Each thread makes an angle θ with the vertical as shown. Show that

$$q = 2L\ sin\theta\sqrt{(mg/k)tan\theta}$$



3. Two equal positive point charges Q are on the x axis at $x = ½\ a$ and $x = -½\ a$.
   a) Obtain an expression for the electric field on the y axis as a function of y.
   b) A bead of mass m, which has charge q, moves along the y axis on a thin frictionless taut thread. Find the electric force that acts on the bead as function of y and determine the sign of q such that this force always points away from, the origin.
   c) The bead is initially at rest at the origin. If it is given a slight nudge in the +y direction, how fast will the bead be traveling the instant the net force on it is a maximum? (Assume any effects due to gravity are negligible.)

4. A point particle that has charge $+q$ and unknown mass m is released from rest in a region that has a uniform electric field E that is directed vertically downward. The particle hits the ground a speed $v = 2\sqrt{gh}$ where h is the initial height of the particle. Find m in terms of E,q, and g.

5. A straight, nonconducting plastic wire of length L carries a charge density of $+Q$ distributed uniformly along its length. It is lying on a horizontal tabletop.
   a) Find the magnitude and direction of the electric field this wire produces at a point d directly above its midpoint.
   b) The wire is bent into a circle lying flat on the table. Find the magnitude and direction of the electric field it produces at a point d directly above its center.

6. A uniform vertical field ***E*** is established in the space between two large parallel plates. A small conducting sphere of mass m is suspended by a string of length L in the region of this field. Find the period of the pendulum when the sphere is given a charge $+q$ and if the lower plate is (a) positively charged, (b) negatively charged.

7. A dipole of moment ***p*** is placed in a uniform electric field that has a magnitude of E. What is the magnitude of the torque on the dipole when

a) the dipole is aligned with the field?

b) the dipole is transverse to (perpendicular to) the electric field?

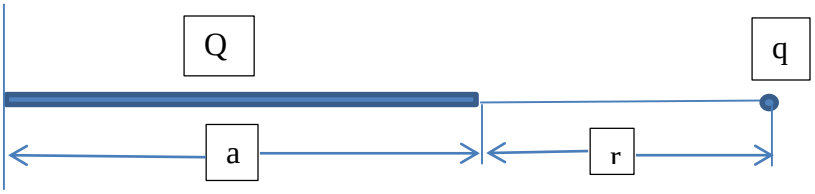
c) the dipole makes an angle θ with the direction of the electric field?

8. Positive charge Q is distributed uniformly along the x-axis from $x = 0$ to $x = a$. A positive point charge q is located on the positive x-axis at $x = a + r$, a distance r to the right of the end of Q.

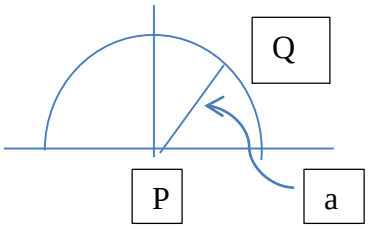
a) Calculate the x and y components of the electric field produced by the charge distribution Q at points on the positive x-axis where $x > a$.

b) Calculate the force (magnitude and direction) that the charge distribution Q exerts on q.

c) Show that if $x >> a$, the magnitude of the force in part (b) is approximately $Qq/4\pi\varepsilon r^2$.



9. Positive charge Q is uniformly distributed around a semicircle of radius a. find the electric field (magnitude and direction) at the center of curvature P.



10. An infinite sheet with positive charge per unit area σ lies in the xy-plane. A second infinite sheet with negative charge per unit area $-\sigma$ lies in the yz-plane. Find the net electric field at all points that do not lie in either of these planes. Express your answer in terms of the unit vectors ***i-hat, j-hat*** and ***k-hat***