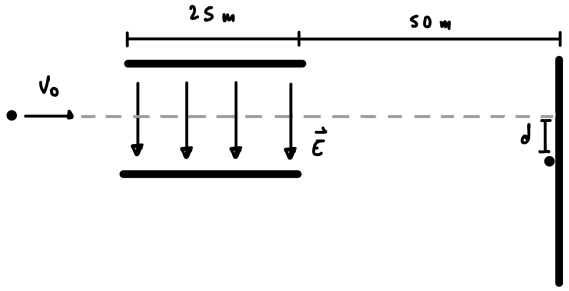
Problem set 8 (due April 15)

1. Consider a uniform (constant) electric field $\vec{E}$.

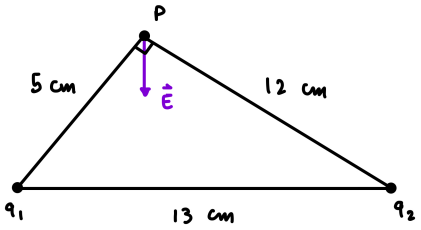
   (a) (1pt) Find the potential energy of a particle with charge q on this electric field

   (b) (1pt) Using the expression above, find the potential energy of a dipole with moment $\vec{d}$

2. (2pts) Consider a particle of mass m, charge q, and initial speed $v_0 = 5 \times 10^3 m/s$ projected into a uniform electric field between two parallel plates of length $25\,m$. The electric field is directed downward between the plates with magnitude $|\vec{E}| = 800\,N/C$ and vanishes outside of the plates. After passing through the field, the object reaches a wall at a distance of $50\,m$, where it is found to have been deflected downward a distance $d = 1.25\,m$. Ignoring gravity and air resistance, compute the object's charge-to-mass ratio q/m.



3. Two charges are placed as shown in the diagram below.

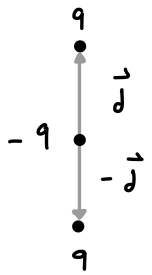


   (a) (1pt) Considering the different possible signs of q_1 and q_2, sketch the four possible electric field configurations $\vec{E}_1$ and $\vec{E}_2$ produced by q_1 and q_2 at point P

   (b) (1pt) Assuming that the net electric field $\vec{E}$ at P is entirely in the negative y direction, deduce the signs of q_1 and q_2

   (c) (1pt) Determine the magnitude of $\vec{E}$ if the magnitude of q_1 is $2 \times 10^{-6}\,C$

4. Consider the configuration of charges shown in the diagram below.



(a) (1pt) Sketch the electric field lines

(b) (1pt) The electric field $\vec{E}$ at a distance $r \gg |\vec{d}|$ can be expanded in powers of $1/r$. The leading term in the expansion falls off as $1/r^n$ for some integer n. Compute the leading term. Does this result fit your expectation? Explain why.

(c) (1pt) Compute the next term in the expansion of the electric field at a distance $r \gg |\vec{d}|$ (that is, the term that goes like $1/r^{n+1}$). Explain why we should expect this result.