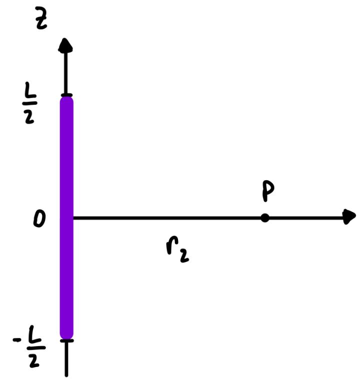
Problem set 11 (due June 5)

1. Consider a line along the z axis of length L and uniform linear charge density λ. It's convenient to use polar coordinates on the xy-plane such that $(x, y, z) = (r_2 \cos\theta, r_2 \sin\theta, z)$.



   (a) (2pt) Compute the electric potential $V(r_2)$ at the point P, located on the xy-plane at $z = 0$ a distance r_2 from the line of charge.

   (b) (2pt) Compute the r_2 component of the electric field at the point P. Is the result compatible with the result of problem 2(a) of problem set 9? Explain why.

   (c) (2pt) In order to obtain the electric potential of an infinitely long line you may want to send $L \to \infty$. However, the answer is divergent! Explain the physical reason why this is happening.

   (d) (1pt) In order to obtain a finite result you can "renormalize" the electric potential by first computing the difference $V(r_2) - V(r_2')$ where $r_2' \neq r_2$ is another position in the xy-plane, and then taking the $L \to \infty$ limit. Write down the result and explain the physical reason why this works.

   (d) (1pt) Use the electric potential obtained above to compute the electric field at r_2. Check that your result matches the electric field of an infinite long line that we found in class.

2. (1pt) An electron moves with a speed of $6 \times 10^6\, m/s$ in a direction perpendicular to Earth's field, which has a strength of $5 \times 10^{-5}\, T$. What strength electric field must be applied perpendicular to the Earth's field to make the electron move in a straight line?

3. (1pt) An oxygen-16 ion with a mass of $2.66 \times 10^{-26}\, kg$ travels at $5 \times 10^6\, m/s$ perpendicular to a $1.20\, T$ magnetic field, which makes it move in a circular arc with a $0.231\, m$ radius. What is the ratio of the the charge of the ion to the charge of the electron? Does this result make sense?