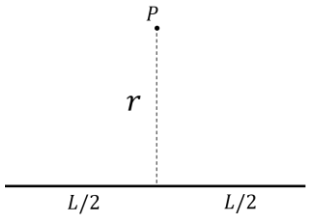
PHYS 401: Electricity & Magnetism 1
Monday, March 15, 2021

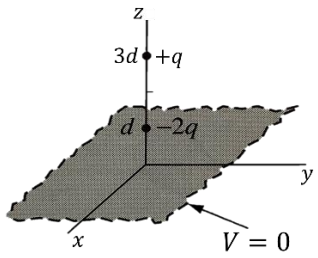
Midterm Test

1. Line charge distribution [25 points]
Consider a line of uniform charge density of length L and total charge Q, as shown in the figure below. Calculate the electric potential V at the point P a distance r away from the center of the line charge. (We will assume that $V = 0$ at an infinite distance from the line charge.)



Note: $\int \frac{dx}{\sqrt{1+x^2}} = \ln\left(x + \sqrt{1+x^2}\right) + C$

2. Charge and conducting plane [25 points]
Find the force (magnitude and direction) on the $-2q$ charge in the figure below. (The xy plane is a grounded conductor.)



3. Electric field of the Earth [25 points]
Careful measurements show that the electric field just above the surface of the Earth is roughly 100 V/m (over the entire surface) and points vertically downwards.

a) Calculate the total charge of the Earth in Coulombs (R_{Earth} = 6378 km).

b) If the Earth were a perfect conductor, then how would this charge be distributed?

c) Calculate the corresponding electric force on an electron near the surface of the Earth and compare it to the gravitational force from the Earth.

d) How can you shield the electron from this force even if it fluctuates in time and space?

Note: $q_e = -1.60 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg and $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/Nm^2.

4. Two spheres [25 points]

Consider a sphere of radius *2a* whose volume has a uniform charge density ρ. A spherical cavity of radius *a* is removed from the sphere, as shown in the figure. Calculate the electric field (vector) within the cavity.