Here are some exercises that target common mistakes from the first exam. Take your time, so you can focus on the content and not the pressure that comes from being on the clock (but don't forget you have homework due next Monday). Email me or stop by if you get stuck. Do the problems corresponding to areas where you had difficulty on the exam and I will restore some of the points you missed. Turn them in to me *with your exam* by Wednesday, October 20. (That should be enough time, but reach out to me if it isn't.) You should work through these on your own – do not collaborate with your classmates.

Problem 1: Potential Energy

Redo problem 1 from the exam if you accidentally calculated the electrostatic potential instead of the potential energy.

Problem 2: Gauss's Law

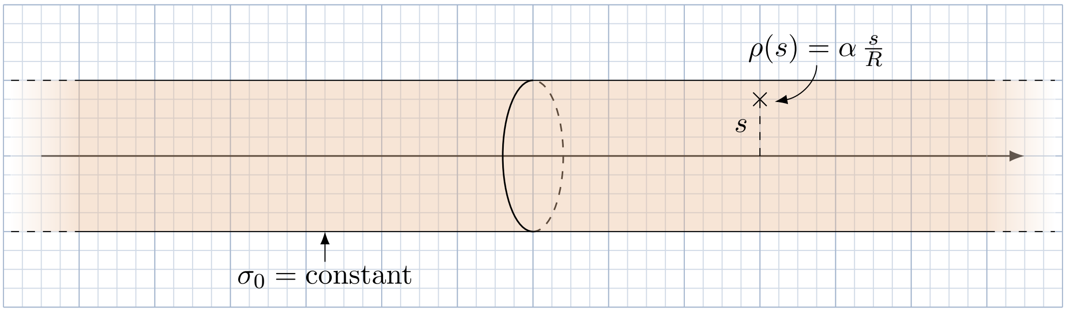
A very long cylinder with radius R has charge distributed throughout its volume and on its surface. The volume charge density changes depending on the distance s from the axis of the cylinder as

$$\rho = \rho_0 \frac{s}{R} , \tag{1}$$

where ρ_0 is just a constant. The charge on the surface is uniform – the surface charge density σ_0 is constant.

(a) Use Gauss's Law to find the electric field inside ($s < R$) and outside ($s > R$) the cylinder. Be clear about your choice of Gaussian surfaces, the flux through these surfaces, and how much charge they contain.

(b) Show that the electric field has the correct discontinuity at the surface of the cylinder ($s = R$).



Problem 3: Two Charged Hemispheres

Charge is spread out over the surface of a sphere of radius R, with positive charge on the upper hemisphere and negative charge on the lower hemisphere

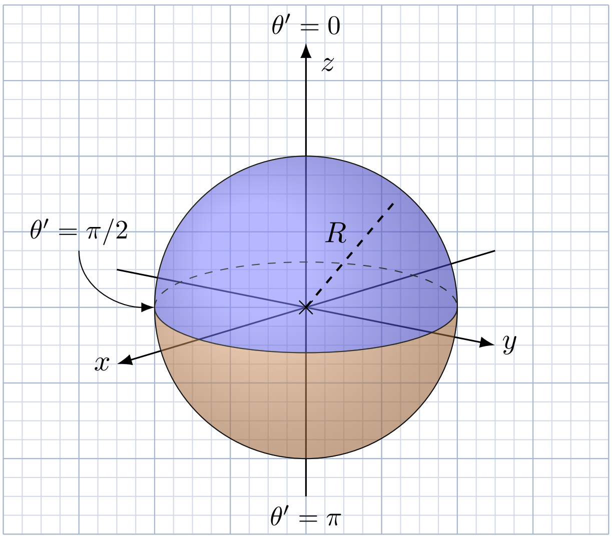
$$\sigma(\theta') = \begin{cases} +\sigma_0 & 0 \le \theta' \le \frac{\pi}{2} \\ -\sigma_0 & \frac{\pi}{2} < \theta' \le \pi \end{cases} . \tag{2}$$

Here σ_0 is a constant and θ' is the usual polar angle (in spherical polar coordinates) for the bit of charge located at $\vec{r}\,'$. The sphere is hollow on the inside – all of the charge is on the surface.

(a) Find the electrostatic potential $V(0,0,z)$ at a point on the z axis. You can assume that $z > 0$, but the point can be either outside ($z > R$, so $\sqrt{(R-z)^2} = z - R$) or inside ($0 < z < R$, so $\sqrt{(R-z)^2} = R - z$) the sphere.

(b) Find the electric field $\vec{E}(0,0,z) = -\partial V(0,0,z)/\partial z$ at points on the positive z-axis for $z > R$ and $z < R$.

In part (a), be sure to clearly set up your calculation by identifying things like $\vec{r}$, $\vec{r}\,'$, and $\vec{\mathscr{r}}$ before writing out the integral you want to evaluate. Remember to use primed coordinates for the location of charge, and unprimed coordinates for the point where we want to know the potential. Finally, since all the charge is on the surface of the sphere, $|\vec{r}\,'| = r\,' = R$.



Problem 2: The surface charge density is positive on the upper hemisphere ($0 < \theta' < \pi/2$), zero at the equator ($\theta' = \pi/2$), and negative on the lower hemisphere ($\pi/2 < \theta' < \pi$).