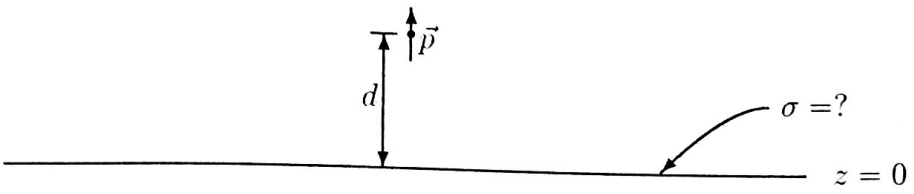
Physics 110A (Electrodynamics) – Midterm Exam / November 4, 2019

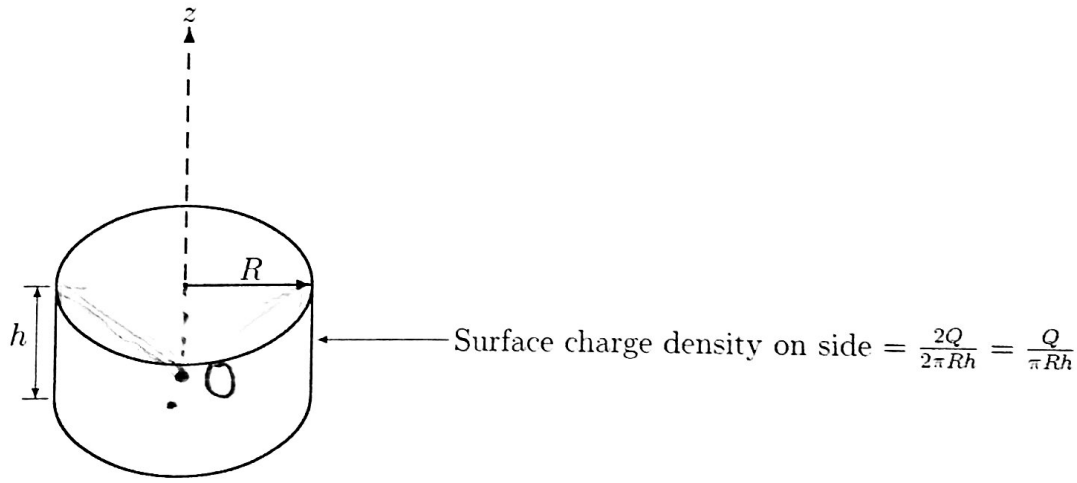
Problem 1 (50 points)



A perfect electric dipole with dipole moment $\vec{p} = p\hat{z}$ is held at height d above an infinite grounded conducting plane. Find the surface charge density σ that is induced on the plane.

Express your result as follows.
If the dipole is at (x, y, z) coordinates $(0, 0, d)$ and the plane is at $z = 0$, express σ as a function of the distance $s = \sqrt{x^2 + y^2}$ from the origin.

Problem 2 (50 points)



A cylinder of height h and radius R is aligned with its axis along the z-axis. A total charge of $+2Q$ is uniformly distributed on each of the two bases (with surface charge density $\sigma = -Q/\pi R^2$), and a total charge of $2Q$ is uniformly distributed on the side (with surface charge density $\sigma' = Q/\pi Rh$).

Find an approximate expression for the electrostatic potential V produced by the cylinder at large distance r away. Assume $r \gg R, h$ and $V \to 0$ as $r \to \infty$.

Express your result in spherical coordinates with the origin at the center of the cylinder (at height $\frac{h}{2}$, not shown in the picture). $V(r, \theta)$ should fall off as a power law in r.

Note: the cylinder is neutral as a whole, i.e., the total charge is $(-Q) + (-Q) + (2Q) = 0$.