Electricity and Magnetism

Do two of the following three problems, each on a separate sheet (or sheets). Attach each set to a provided cover sheet with your name, subject, and problem number.
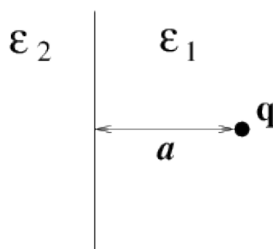
Problem 1

Consider the region bounded by the planes $x = 0$, $x = a$, $y = -a/2$ and $y = a/2$. The boundaries at $x = 0$ and $x = a$ are held at zero potential. The potential on the boundaries at $y = -a/2$ and $y = a/2$ is given by

$$V(x, -a/2) = V(x, a/2) = V_0 \sin(\pi x/a) \ .$$

Find the electrostatic potential $V(x, y)$ inside this region by solving the Laplace equation using the method of separation of variables.

Problem 2

A point charge q is located at a distance a from an infinite flat surface separating two dielectrics of permittivities ϵ_1 and ϵ_2. Find the electrostatic force on the charge q. When would this force be attractive and when would it be repulsive?

Problem 3

Consider an infinitely long magnetized cylinder of radius R with a magnetization $\vec{M} = as^2 \hat{z}$, where α is a constant. In other words, the magnetization is parallel to the cylinder axis and proportional to the distance s away from that axis.

a) Compute the bound volume and surface currents per unit length of the cylinder.

b) What is the net bound current?