**Problem 12)** The pill-box's top and bottom surface areas are $\Delta s$. The pill-box can be made as thin as desired, so the side-walls may be assumed to contribute negligibly to the overall surface integral. On the top surface of the box, the surface-normal (pointing outward) is parallel to $\boldsymbol{N}$, so the top surface-integral is $(\boldsymbol{E}_1 \cdot \boldsymbol{N})\Delta s = E_1^{\perp}\Delta s$. On the bottom surface, the surface-normal (again pointing outward) is anti-parallel to $\boldsymbol{N}$; therefore, the bottom surface-integral is $-(\boldsymbol{E}_2 \cdot \boldsymbol{N})\Delta s = -E_2^{\perp}\Delta s$. Consequently, the net integral of $\boldsymbol{E}$ is given by $\oint \boldsymbol{E} \cdot \mathrm{d}\boldsymbol{s} = (E_1^{\perp} - E_2^{\perp})\Delta s$. Since the total charge enclosed by the pill-box is $Q = \sigma(\boldsymbol{r})\Delta s$, Gauss's law yields $\sigma(\boldsymbol{r}) = \varepsilon_o (E_1^{\perp} - E_2^{\perp})$.