Exercise 6

[1] Obtain the radial and azimuthal components of electric field in terms of \( r \) and \( \theta \), when an electrostatic potential made by a dipole

\[
\Phi = q \left( \frac{1}{r_1} - \frac{1}{r_2} \right)
\]

is given as in the figure. As a reminder, in polar coordinates,

\[
\nabla f = \frac{\partial f}{\partial r} \hat{r} + \frac{1}{r} \frac{\partial f}{\partial \theta} \hat{\theta}.
\]

[2] (Schwartz 2-3) Find the energy stored in a uniform, spherical charge distribution of radius \( R \) and total charge \( Q \). For now, you can estimate the stored energy by

\[
U = \frac{1}{8\pi} \int_{\text{all space}} E^2 dV.
\]

[3] (Schwartz 2-4) A charge \( Q \) is deposited on a spherical conductor of radius \( R \). What is the energy of the distribution?

[4] (Schwartz 2-5) Two long, concentric conducting cylinders have radii \( a \) and \( b \), respectively, and are each of length \( l \). The space between them is filled with material having dielectric constant \( \varepsilon \). If the potential difference between the cylinder is \( V \), find the total energy stored in the fields between them.