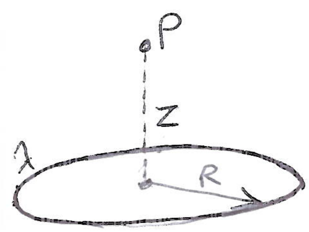
Test 1 (Practice)

E & M

(1) Find the electric field a distance z above the center of a circular loop of radius R carrying a uniform line charge density λ per unit length



(2) If the electric field is $\underline{E} = k r^3 \hat{\underline{r}}$ in spherical polar coordinates (k is a constant):

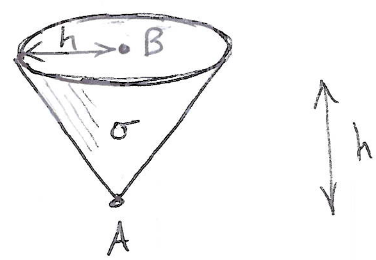
(a) Find the charge density ρ

(b) Find the total charge inside a sphere of radius R, centered at the origin, in two different ways:

(i) by integrating ρ

(ii) using Gauss law.

(3) A conical surface (an empty ice-cream cone) carries a uniform surface charge density σ per unit area. The height of the cone and the radius of the top are both h. Find the electric potential difference between the vertex A and center of the top B



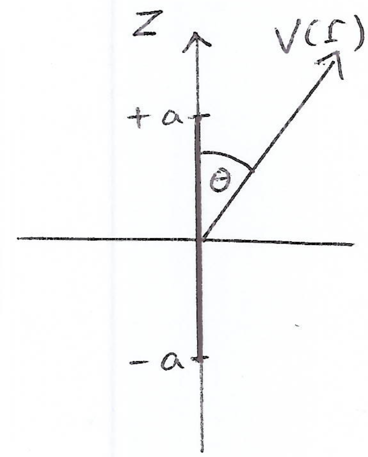
(Math hint: Complete square in denom.)

$$\left[\int \frac{dx}{\sqrt{1+x^2}} = \ln \left| x + \sqrt{1+x^2} \right| \right]$$

E & M Test 2 (Practice)

[5 points each problem]

① A thin insulating rod, running from $z = -a$ to $z = +a$, carries a linear charge density $\lambda = K \sin(\pi z / a)$. Find the monopole and dipole terms of the multipole expansion of $V(\mathbf{r})$



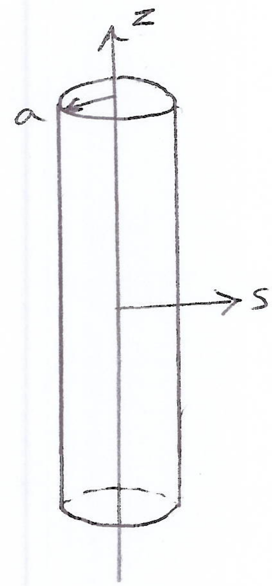
② A point charge q is at the center of a sphere of linear dielectric material (susceptibility χ_e, radius R).

Find a) $\mathbf{E}$ electric field
b) $\mathbf{P}$ polarization
c) ρ_b bound volume charge density
d) σ_b bound surface charge density

③ Find the potential outside a charged metal sphere (charge Q, radius R) which is placed in an otherwise uniform electric field $\mathbf{E} = E_0 \hat{z}$. Explain clearly where you are setting the zero of potential, and sketch the electric field outside the sphere.

E & M Test 3 (Practice) [5 points each problem]

① An infinitely long cylindrical wire of radius a carries a steady current density $\underline{J} = K s \hat{\underline{z}}$ where K is a constant, $\hat{\underline{z}}$ is parallel to the wire, and s is the perpendicular distance to the wire axis. Find the magnetic field $\underline{B}$ inside and outside the wire.

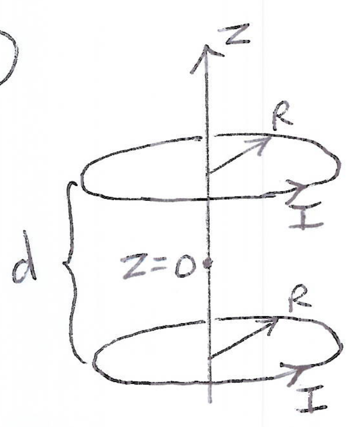


② An infinitely long cylinder, of radius R, carries a magnetization parallel to the cylinder axis $\underline{M} = K s \hat{\underline{z}}$ where K is a constant and s is the distance from the axis. Find the magnetic field $\underline{B}$ inside and outside the cylinder:

a) by calculating the bound currents

b) Using Ampère's law for $\underline{H}$

③



[HINT: Use Ex 5.6]

A Helmholtz coil consists of two identical current loops as shown. This is designed to produce an approximately constant $\underline{B}$ field between the loops. Show that at $z=0$ on axis, $\frac{\partial \underline{B}}{\partial z} = 0$ and find the separation d for which $\frac{\partial^2 B}{\partial z^2} = 0$