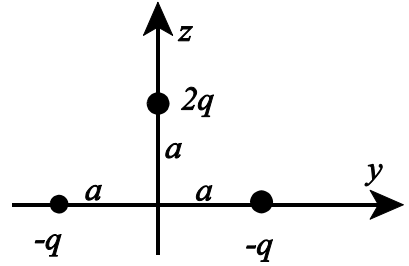


1. (25 pts) Three charges lie in the yz plane as shown. There is a charge $+q$ at $y = -a$, a charge $+q$ at $y = a$, and a charge $2q$ at $z = a$.



a) Calculate the monopole and dipole moments for this distribution.

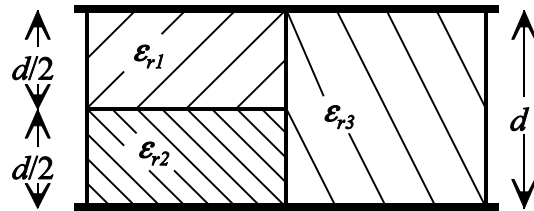
b) Find the approximate potential at points far from the distribution. Give your results in spherical coordinates.

2. (25 pts) A thick spherical shell (inner radius a , outer radius b) is made of dielectric material with a “frozen-in” polarization $\vec{P}(\vec{r}) = Ar^3 \hat{r}$, where A is a constant and r is the distance from the center. There is no free charge in the problem.

a) Calculate all the bound charges and then use Gauss’s Law for \vec{E} to calculate the field in all three regions.

b) Determine the potential at the center of the thick spherical shell, *i.e.*, at $r = 0$.

3. (25 pts) A parallel plate capacitor is filled with three dielectrics with dielectric constants ϵ_1 , ϵ_2 , and ϵ_3 as shown. Half the capacitor is filled with ϵ_3 . The other half is divided equally between ϵ_1 and ϵ_2 . Determine the capacitance of the arrangement in terms of the original capacitance C_0 with no dielectric



material present ($C_0 = \epsilon_0 A/d$). The area of a plate is A and d is the distance between the plates.

4. (25 pts) A sphere of linear dielectric material, radius R , and dielectric constant ϵ_r is placed in an otherwise uniform electric field \vec{E}_0 .

a) Determine the potential inside and outside the sphere.

b) Determine the electric field inside the sphere.

c) What is the dipole moment of the sphere?