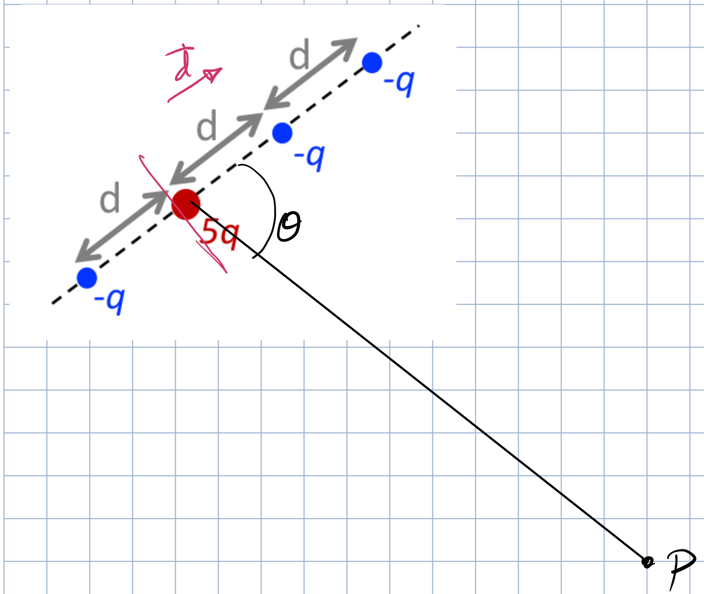
$$\vec{A} = \frac{\mu_0}{4\pi}\int \frac{J(\vec{r}')\,d\tau'}{R} = \frac{\mu_0}{4\pi}\int \frac{I\,d\vec{l}'}{|\vec{r}-\vec{r}'|} = \frac{\mu_0}{4\pi}\frac{1}{r^{l+1}}\int P_l(\cos\theta')(r')^l\,dl'$$

$$= \frac{\mu_0}{4\pi}\left[\cancel{\frac{1}{r}\oint dl'} + \frac{1}{r^2}\oint r'\cos\theta'\,dl + \dots\right]$$

$$= \frac{\mu_0}{4\pi}\frac{1}{r^2}\cdot\int(\vec{r}'\cdot\hat{r})\,dl$$

#2 on Midterm 2



$$Q_{tot} = 2q \neq 0$$

$$V_{mono} = \frac{1}{4\pi\epsilon_0}\frac{Q_{tot}}{r^2}$$

dependent on coordinate system

$$\vec{p} = \int \vec{r}'\rho(\vec{r}')\,d\tau' = \sum \vec{r}'\,q_i$$

$$= -q(-\vec{d}) + 5q(0) + (-q)(\vec{d}) + (-2q)(2\vec{d})$$

$$= \vec{d}(+q-q-2q) = -2q\vec{d}$$

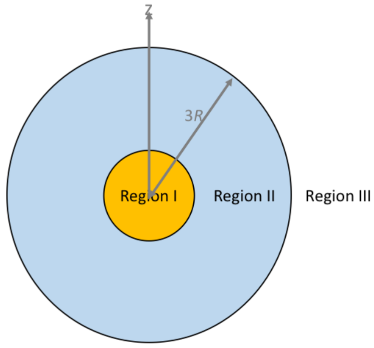
$$V_{dip} = \frac{1}{4\pi\epsilon_0}\frac{\vec{p}\cdot\hat{r}}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{-2qd\cdot\cos\theta}{r^2}\hat{r}$$

$$V_{quad} = \frac{1}{4\pi\epsilon_0}\left[\frac{1}{r^3}\int r'^2\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)d\tau\right]$$

$$= \frac{1}{4\pi\epsilon_0}\frac{1}{r^3}\sum_i (r_i')^2\cdot q_i\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right)$$

Consider a sphere of radius $3R$ and three Regions:

- Region I = a concentric sphere with radius R
- Region III = outside of the sphere with radius $3R$
- Region II = between Region I and Region III



Assume that

- electric potential in Region I is $V(I) = C_1$
- electric potential in Region III is $V(III) = C_3 \frac{3R}{r} \cos\theta$

where C_1 and C_3 are constant, r is radial distance from the center of the spheres and θ is the polar angle from the z direction.

Calculate the electric potential in Region II, using the "separation of variables" method.

Hint: You can solve this problem by writing down potentials in the three regions and applying two boundary conditions: one at r=R and the other at r=3R.

$$V_I = C_1 \cdot P_0 + 0 \cdot P_1 + 0 \cdot P_2 + \cdots$$

$$V_{II} = \sum_l \left(A_l r^l + \frac{B_l}{r^{l+1}}\right) P_l(\cos\theta)$$

$$V_{III} = C_3 \frac{3R}{r} \cos\theta = C_3 \frac{3R}{r} P_1$$

	$l=0$	$l=1$	$l>1$
V_I	C_1	0	0
V_{II}	$\left(A_0 + \frac{B_0}{r}\right) P_0$	$\left(A_1 r + \frac{B_1}{r^2}\right) P_1$	$\left(A_l r^l + \frac{B_l}{r^{l+1}}\right) P_l$
V_{III}	0	$C_3 \frac{3R}{r} P_1$	0

$@\ r=R \qquad A_0 + \frac{B_0}{R} = C_1$

$@\ r=3R \qquad A_0 + \frac{B_0}{3R} = 0$