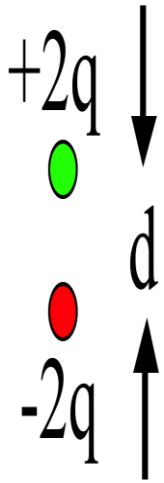
MULTIPOLE EXPANSION

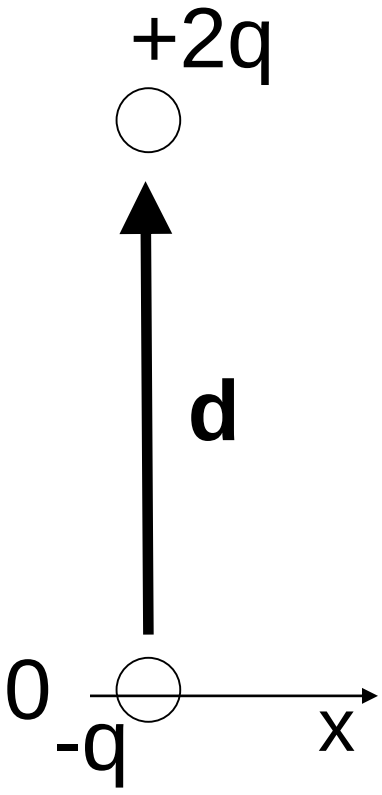
$$\vec{p} = \sum_i q_i \vec{r}_i$$

What is the magnitude of the dipole moment of this charge distribution?



A) qd
B) 2qd
C) 3qd
D) 4qd
E) It's not determined

$$\vec{p} = \sum_i q_i \vec{r}_i$$



What is the dipole moment of this system?
(Note: it is NOT overall neutral!)

A) $q\vec{d}$

B) $2q\vec{d}$

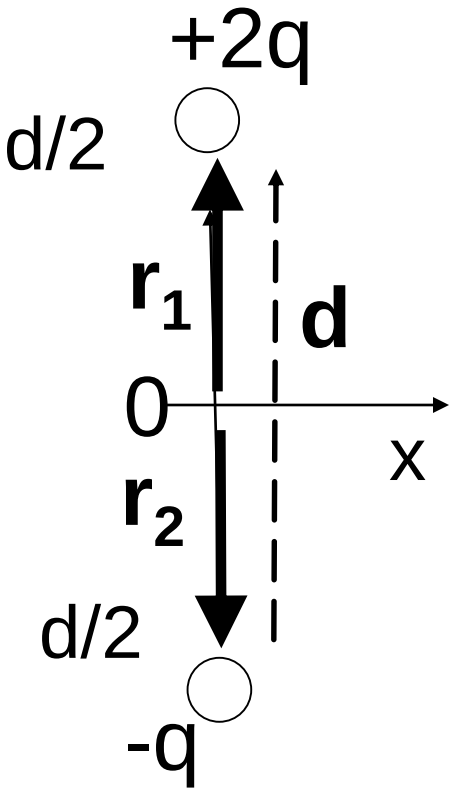
C) $\frac{3}{2}q\vec{d}$

D) $3q\vec{d}$

E) Something else

(or, not defined)!

$$\vec{p} = \sum_i q_i \vec{r}_i$$



What is the dipole moment of this system?

(Note: same as last question, just shifted in z!)

A) $q\vec{d}$

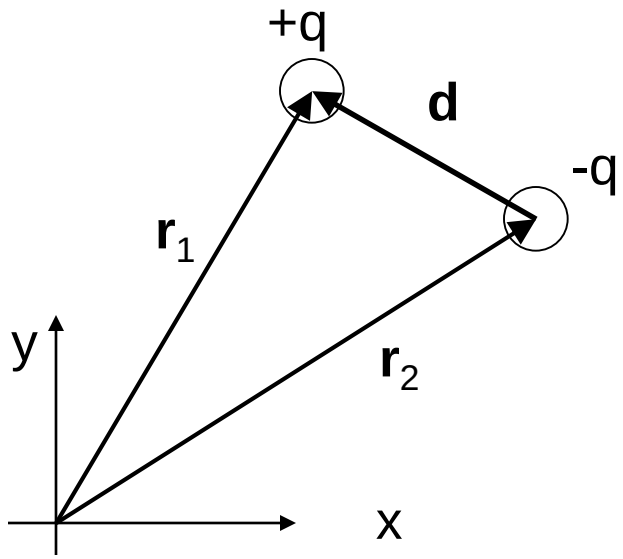
B) $2q\vec{d}$

C) $\frac{3}{2}q\vec{d}$

D) $3q\vec{d}$

E) Something else

(or, not defined)!



$$\sum_i q_i \vec{r}_i = ?$$

A) $+q\vec{d}$

B) $-q\vec{d}$

C) zero

D) None of these, it's more complicated now!

A small dipole (dipole moment p=qd) points in the z direction.
We have derived $V(r) \approx \frac{1}{4\pi\varepsilon_0}\frac{qd\cos\theta}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{qdz}{r^3}$

Which of the following is correct (and "coordinate free")?

A) $V(r) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\times\hat{r}}{r^2}$

B) $V(r) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\times\hat{r}}{r^3}$

C) $V(r) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}\times\vec{r}}{r^2}$

D) $V(r) = \frac{1}{4\pi\varepsilon_0}\frac{\vec{p}'\ \hat{r}}{r^2}$

E) None of these

You have a physical dipole, +q and -q a finite distance d apart.
When can you use the expression:

$$V(\vec{r}) = \frac{1}{4\pi\epsilon_0}\frac{\vec{p}\times\hat{r}}{r^2}$$

A) This is an exact expression everywhere.

B) It's valid for large r

C) It's valid for small r

D) ?

You have a physical dipole, +q and -q, a finite distance d apart.
When can you use the expression

$$V(r) = \frac{1}{4\pi\varepsilon_0}\sum \frac{q_i}{\mathfrak{R}_i}$$

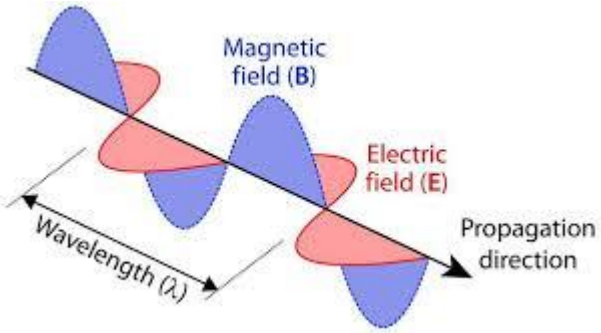
A) This is an exact expression everywhere.

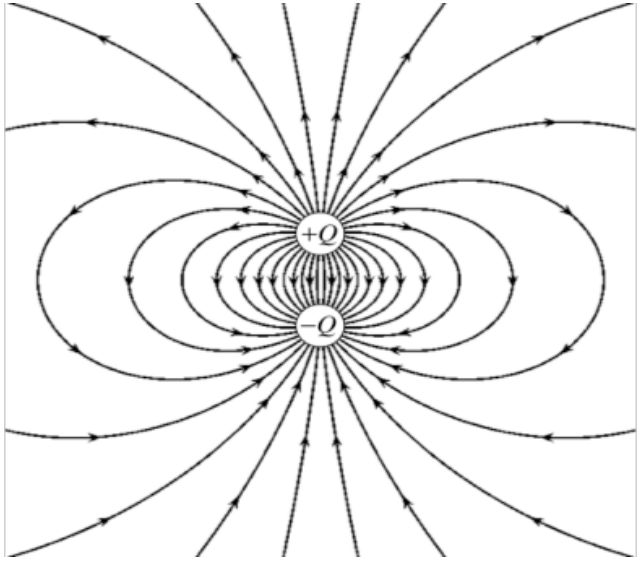
B) It's valid for large r

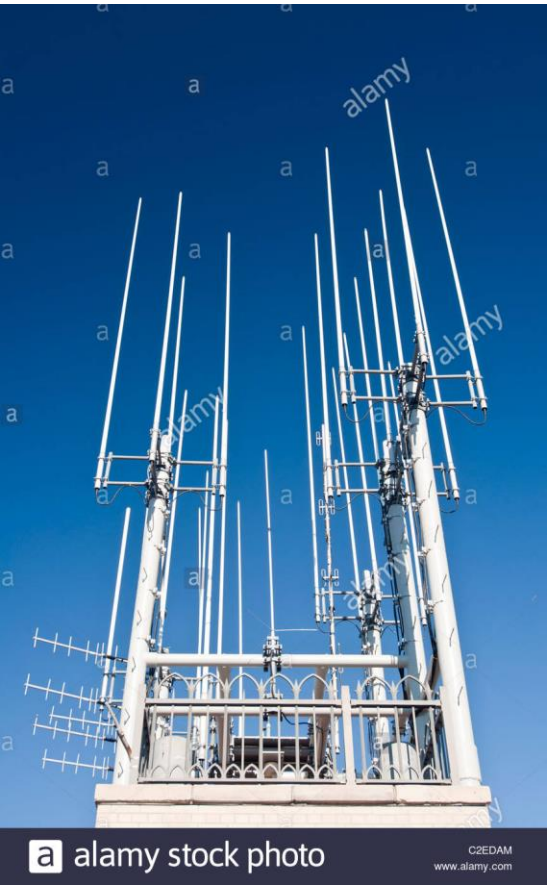
C) It's valid for small r

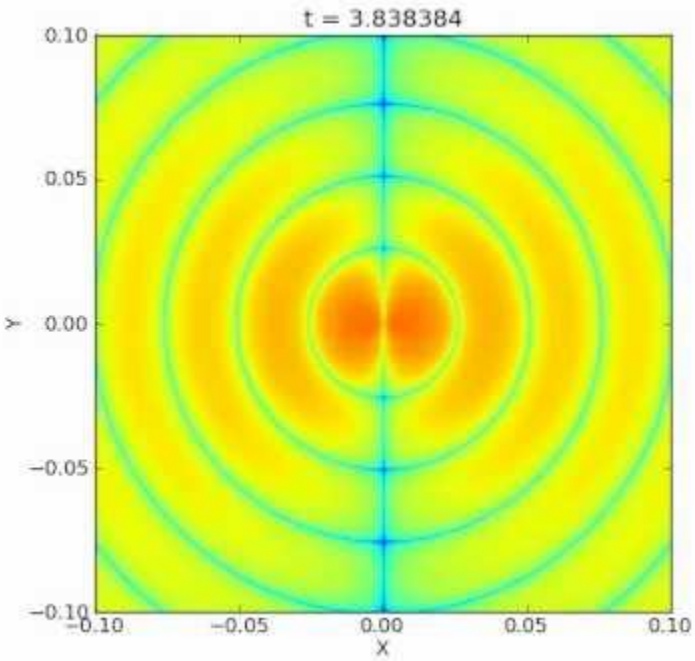
D) ?

Electric Dipole Radiation



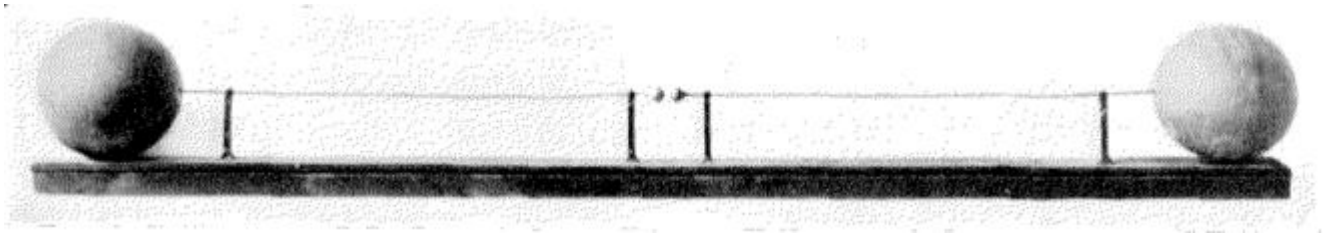




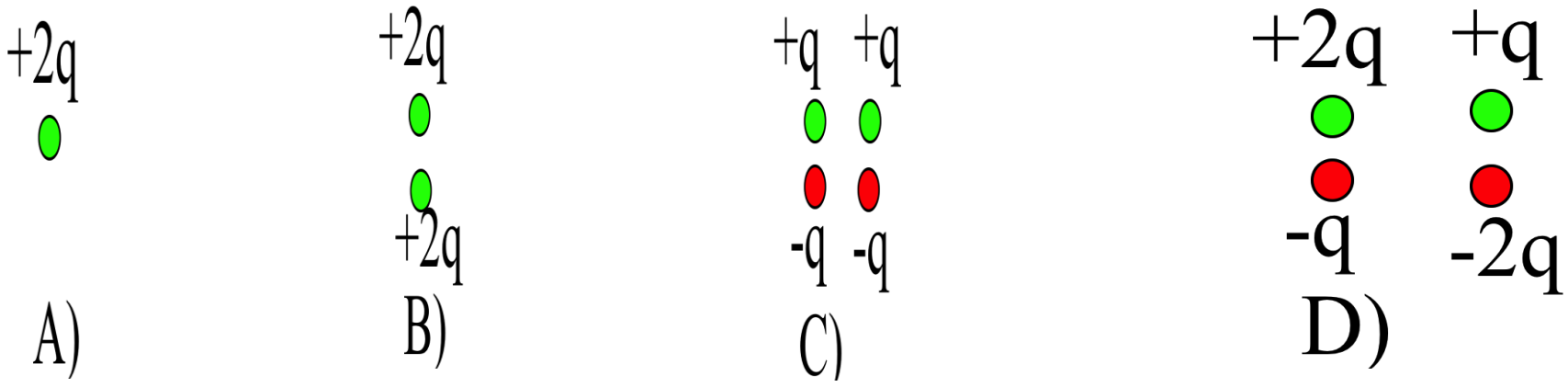


Heinrich Hertz
(1857 – 1894) German physicist, first conclusively proved the existence of the electromagnetic waves theorized by James Clerk Maxwell

Asked about the applications of his discoveries, Hertz replied, "Nothing, I guess."



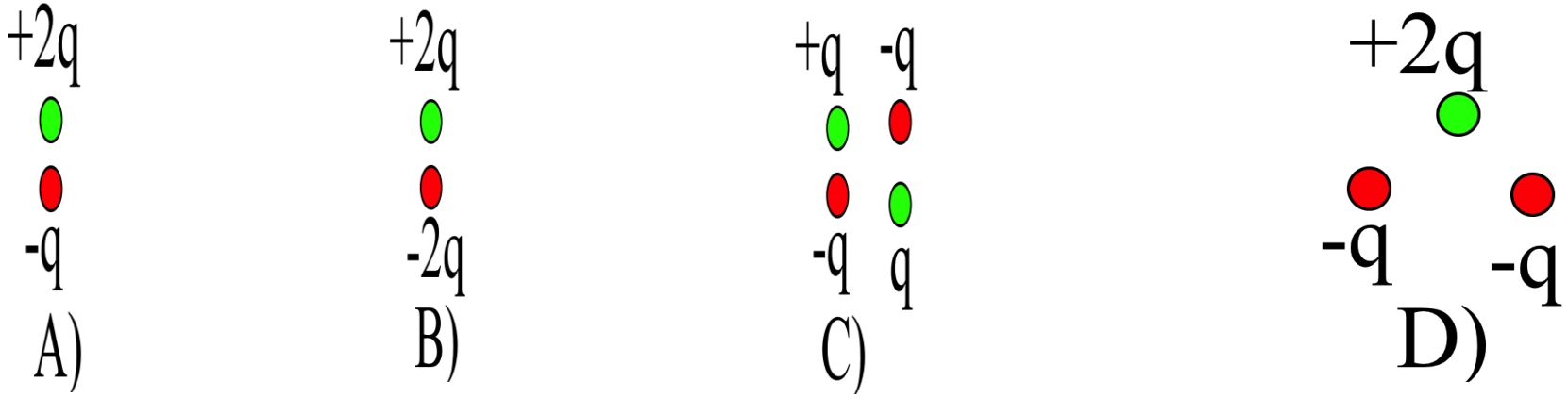
Which charge distributions below produce a potential which looks like C/r^2 when you are far away?



E) None of these, or *more* than one of these!

(Note: for any which you did not select, how DO they behave at large r?)

Which charge distributions below produce a potential which looks like C/r^2 when you are far away?

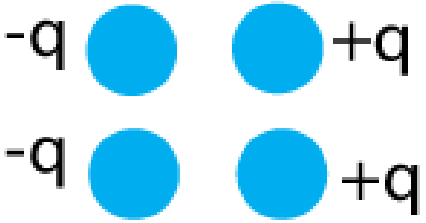


E) None of these, or *more* than one of these!

(Note: for any which you did not select, how DO they behave at large r?)

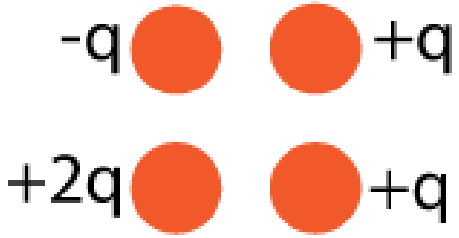
In which situation is the dipole term the leading non-zero contribution to the potential?

A



B

C



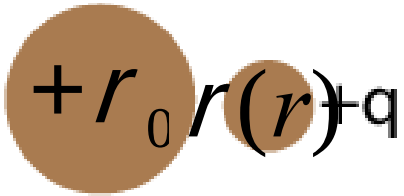
A) A and C

B) B and D

C) only E

D) A and E

E) Some other combo

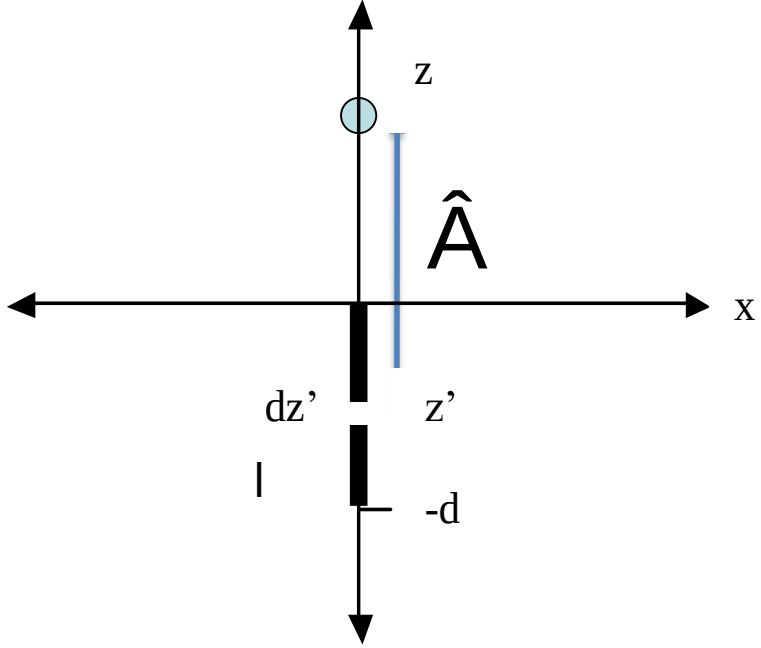


D

$s = s_0 \cos(q)$

E

$$V(z) = \frac{1}{4\pi\varepsilon_o} \int \frac{\rho_l \, dz'}{\mathcal{R}}$$



$$= \frac{1}{4\pi\varepsilon_0} \int_{z'=-d}^{z'=0} \frac{\rho_l \, dz'}{(z - z')} \quad \text{if } z>0$$

$$= \frac{\rho_l}{4\pi\varepsilon_0}(-)\ln(z - z')\Big|_{-d}^{0}$$

$$= \frac{\rho_l}{4\pi\varepsilon_0}\ln\left(\frac{z+d}{z}\right)$$