Home work: hand in required

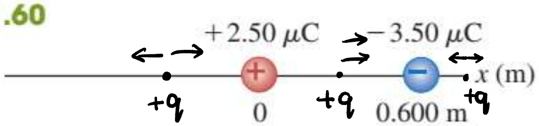
21.1 •• Excess electrons are placed on a small lead sphere with mass 8.00 g so that its net charge is -3.20×10^{-9} C. (a) Find the number of excess electrons on the sphere. (b) How many excess electrons are there per lead atom? The atomic number of lead is 82, and its atomic mass is 207 g/mol.

21.7 •• An average human weighs about 650 N. If each of two average humans could carry 1.0 C of excess charge, one positive and one negative, how far apart would they have to be for the electric attraction between them to equal their 650-N weight?

21.59 ••• Four identical charges Q are placed at the corners of a square of side L. (a) In a free-body diagram, show all of the forces that act on one of the charges. (b) Find the magnitude and direction of the total force exerted on one charge by the other three charges.

21.60 ••• Two charges are placed on the x-axis: one, of 2.50 μC, at the origin and the other, of $-3.50\ \mu$C, at $x = 0.600$ m (**Fig. P21.60**). Find the position on the x-axis where the net force on a small charge $+q$ would be zero.

Figure **P21.60**



21.1

(a) Net charge: $-3.20\times10^{-9}C$

$$N=\frac{-3.20\times10^{-9}C}{-1.6\times10^{-19}C}=2\times10^{10}$$

There are 2×10^{10} electrons on the sphere.

(b) $n=\dfrac{2\times10^{10}}{8\div207\times6.02\times10^{23}}=8.59\times10^{-13}$

There are 8.59×10^{-13} electrons per lead atom.

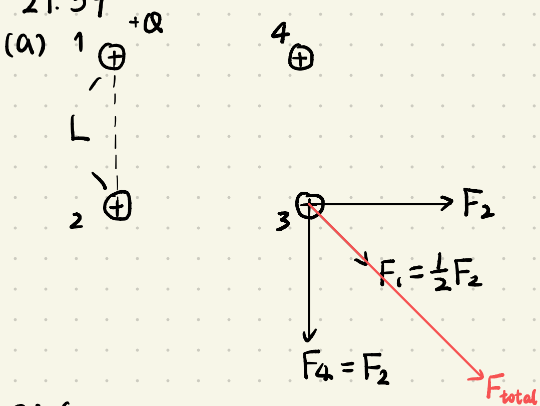
21.7 $F=k\dfrac{q_1q_2}{r^2}=650N$

$$\frac{9\times10^{9}}{r^2}=650\rightarrow r=3721.04m$$

They should be 3721.04m.

21.59

(a)



(b) $F_2=\dfrac{1}{4\pi\epsilon_0}\dfrac{Q^2}{L^2}=F_4$

$F_1=\dfrac{1}{4\pi\epsilon_0}\dfrac{Q^2}{2L^2}=\dfrac{Q^2}{8\pi\epsilon_0L^2}$

$F_{total}=\dfrac{(2\sqrt{2}+1)Q^2}{8\pi\epsilon_0L^2}$

The direction of F_{total} is the same as F_1.

21.60

① $x<0$: $k\dfrac{2.5q}{x^2}=k\dfrac{3.5q}{(x-0.6)^2}$

$7x^2=5x^2-6x+1.8$

$x=-3.2748(m)$

② $0<x<0.6$: Not applicable, $F\neq0$

③ $x>0.6$: $k\dfrac{2.5q}{x^2}<k\dfrac{3.5q}{(x-0.6)^2}$, $F\neq0$

$\therefore$ The position is $x=-3.2748m$.

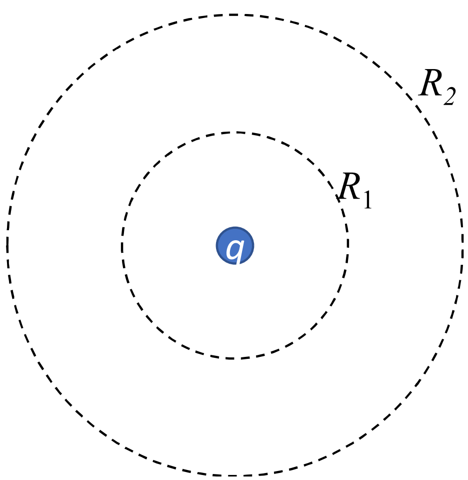
Home work: hand in required

If the electric field follows the follow rule, instead of the inverse square law.

$$\vec{E} = k\frac{Q}{r^3}\hat{r}$$

1. Please calculate the surface integral of the field on a sphere of radius R_1.
2. How about R2?
3. Can you please draw the filed line? According to the rules of field line, it should be along the direction of the field, and the density of the lines should be proportional to the magnitude of the field.
4. What will the field line look if the field follows the following equation.

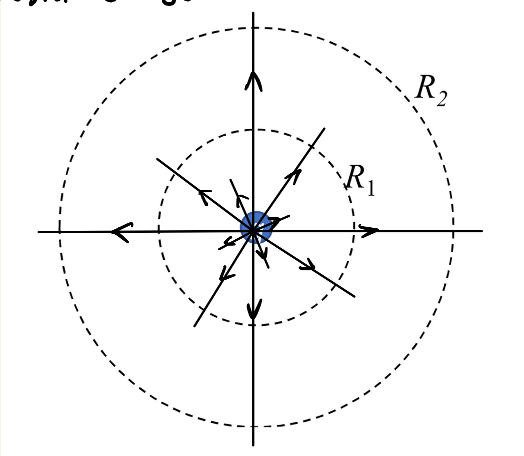
$$\vec{E} = k\frac{Q}{r}\hat{r}$$



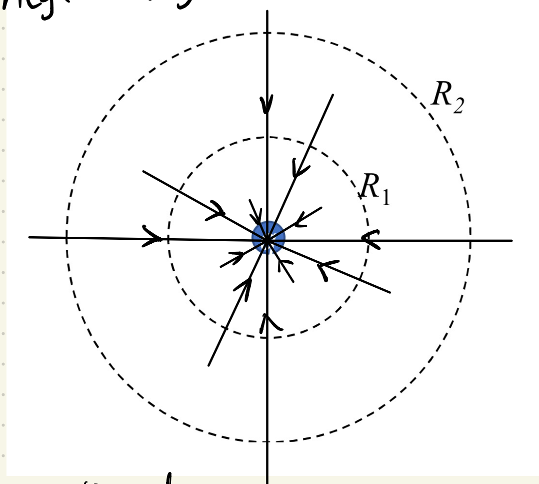
1. $\oiint_{\partial\Omega} \vec{E}_1 \cdot d\vec{S}_1 = \oiint_{sphere} k\frac{q}{R_1^3}\, d\vec{S}_1 = k\frac{q}{R_1^3} \cdot 4\pi R_1^2 = \frac{q}{R_1 \cdot \epsilon_0}$

2. $\oiint_{\partial\Omega} \vec{E}_2 \cdot d\vec{S}_2 = \frac{q}{R_2 \cdot \epsilon_0}$

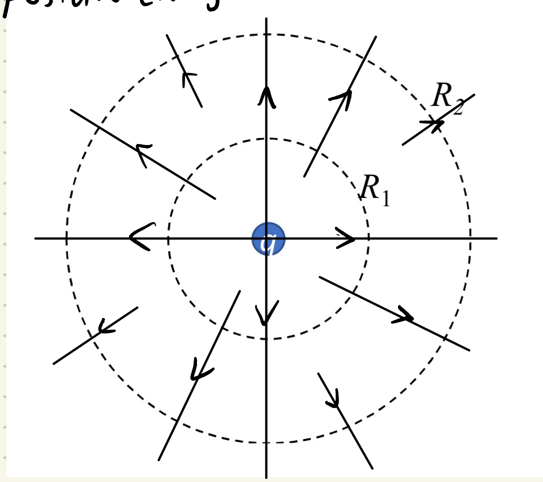
3. positive charge



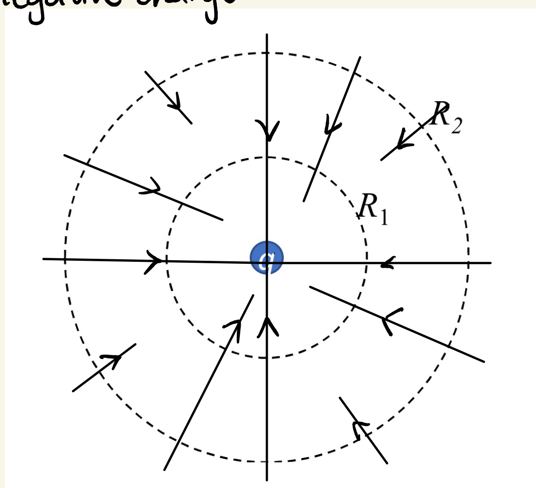
negative charge



4. positive charge



negative charge



Explanation:

For problem 3, $E = \frac{kQ}{r^3}\hat{r}$, which indicates that the electric field will reduce much more dramatically when the r increases. For problem 4, $E = \frac{kQ}{r}\hat{r}$, the electric field will reduce much more slowly when the r increases. The magnitude is determined by the Gauss's Law, as $\phi = \oint \vec{E} \cdot d\vec{A}$. Meanwhile, the direction remains unchanged according to Coulumb's Law, as $\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$, so the direction of a positive charge is always pointing away from the center, and that of a negative charge is always pointing towards the center.