1

Phys 2426 2016-09-06 Lec 4

Current Materials: Chap 23-26

HW 1-15: $\ominus$ $-3.1\,\mu C$ $\oplus$ $+6.2\,\mu C$

Where is $\vec{E} = 0$?

What is $\vec{E}$? $\vec{E} = \vec{E}_1 + \vec{E}_2$

How can two vectors add to zero?

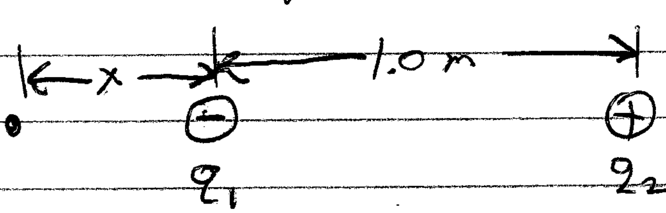
- Equal & Opposite.

How can they be equal in magnitude?

$$E_1 = \frac{k|q_1|}{r_1^2} \qquad E_2 = \frac{kq_2}{r_2^2}$$

- Must be closer to weaker charge.

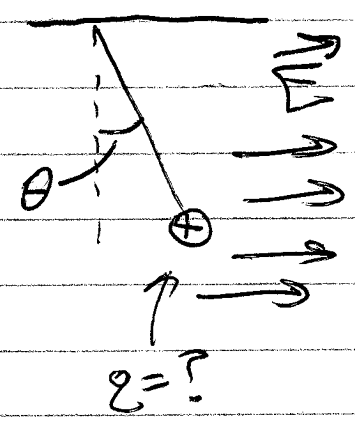
$$\frac{k|q_1|}{r_1^2} = \frac{kq_2}{r_2^2}$$

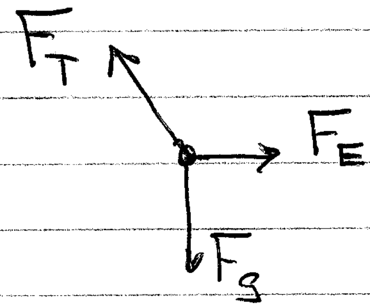


$r_1 = x$ $r_2 = x + 1$

2

HW1-18





x: $F_E - F_T \, \underline{\sin\theta} = 0$

y: $F_T \, \underline{\cos\theta} - F_g = 0$

When $\theta = 0$, $\vec{F}_T$ is (up). $\cos 0 = 1$
$\sin 0 = 0$

To get F_T to stay in y-eqn when $\theta = 0$, $\cos\theta$ must go in y-eqn.

③

Elec Field vs. Elec Potential
aka Potential Difference
aka Voltage
aka EMF

	Elec Field	Elec Potential
Units	$\frac{N}{C} = \frac{V}{m}$	$V = \frac{J}{C} = \frac{Nm}{C}$
Dynamics	$\vec{E} = \frac{\vec{F}}{q_0}$	$\Delta V = \frac{\Delta U}{q_0}$
	$\vec{E} = -\frac{dV}{dx}$	$\Delta V = -\int E_x\, dx = -\int \vec{E} \cdot \vec{dl}$

Point charge

$+q_1$
(source)

$$E = \frac{kq}{r^2}$$

what is ΔV?

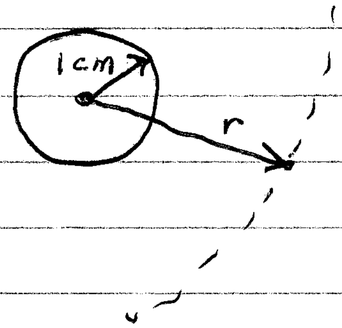
$$\Delta V = -\int_a^b \frac{kq}{r^2}\, dr$$

$$= -kq \left[\frac{-1}{r}\right]_a^b$$

$V = \frac{kq}{r}$ (Potential of point charge.)

Let's try to store charge on a metal ball.

Charge: Q



Gauss: $\Phi_E = 4\pi k Q_{enc}$

$$\cancel{4\pi} r^2 E = \cancel{4\pi} k Q$$

E-Field: $E = \dfrac{kQ}{r^2}$

From the outside, our ball "looks like" a point charge.

Energy per charge?

$$V = \frac{kQ}{r} \quad \text{near the ball}$$

On the ball:

$$V = \frac{kQ}{r_{ball}}$$

With 5.0 V, how much charge?

$$Q = \frac{rV}{k} = \frac{(0.01\,m)(5.0\,V)}{(9\times10^9\ Nm^2/C^2)}$$

$$= 5.6\times10^{-12}\ C$$

5

How much energy does it store?

$$? \; Energy = Q \Delta V \; ?$$

Not really.

$$\Delta V = \frac{kQ}{r}$$

First bit of charge dq "sees" $Q = 0$, $\Delta V = 0$, takes no energy.

Last bit dq "sees" Q = full Q, Full ΔV, max energy.

On average, $\Delta V = \frac{1}{2} V_f$

$$Energy = \frac{1}{2} Q V$$

$$= \frac{1}{2}(5.6 \times 10^{-12}\ C)(5.0\ J/C)$$

$$= 1.4 \times 10^{-11}\ J$$

1 cm ball @ 5.0 V

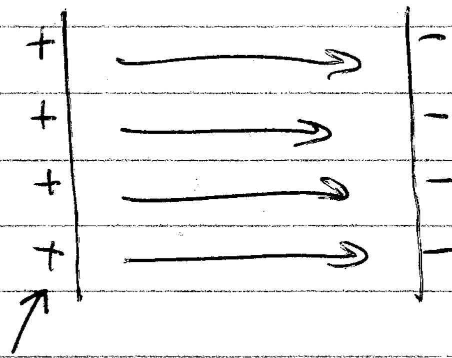
Problems:

- Too hard to store significant energy
- E near the ball is sizeable

Solution:

- Capacitor

Parallel Plate Capacitor



- repelled by each other
- also attracted to $\ominus$, buffers the repulsion.
- allows more $\oplus$ to gather.

E between plates: $E = 4\pi k \sigma = 4\pi k Q/A$

charge per area

Voltage: $\Delta V = E \cdot d = \dfrac{4\pi k Q d}{A} = \dfrac{Qd}{\varepsilon_0 A}$

Let's say $A = (0.01\ m)^2 = 0.0001\ m^2$

$d = 0.001\ m$

$\Delta V = 5.0\ V$

$$Q = \frac{\varepsilon_0 A}{d} \Delta V = \frac{A}{4\pi k d} \Delta V$$

$$= 4.4 \times 10^{-12}\ C$$

Easy to get $A = 1\ m^2$ $d = 1\ \mu m$

$$Q = 4.4 \times 10^{-5}\ C$$