Physics 201 Day 8

Quiz 1 : Point Charges

46 students are taking quiz 1
+1

3 hats
5 lefties
10 glasses

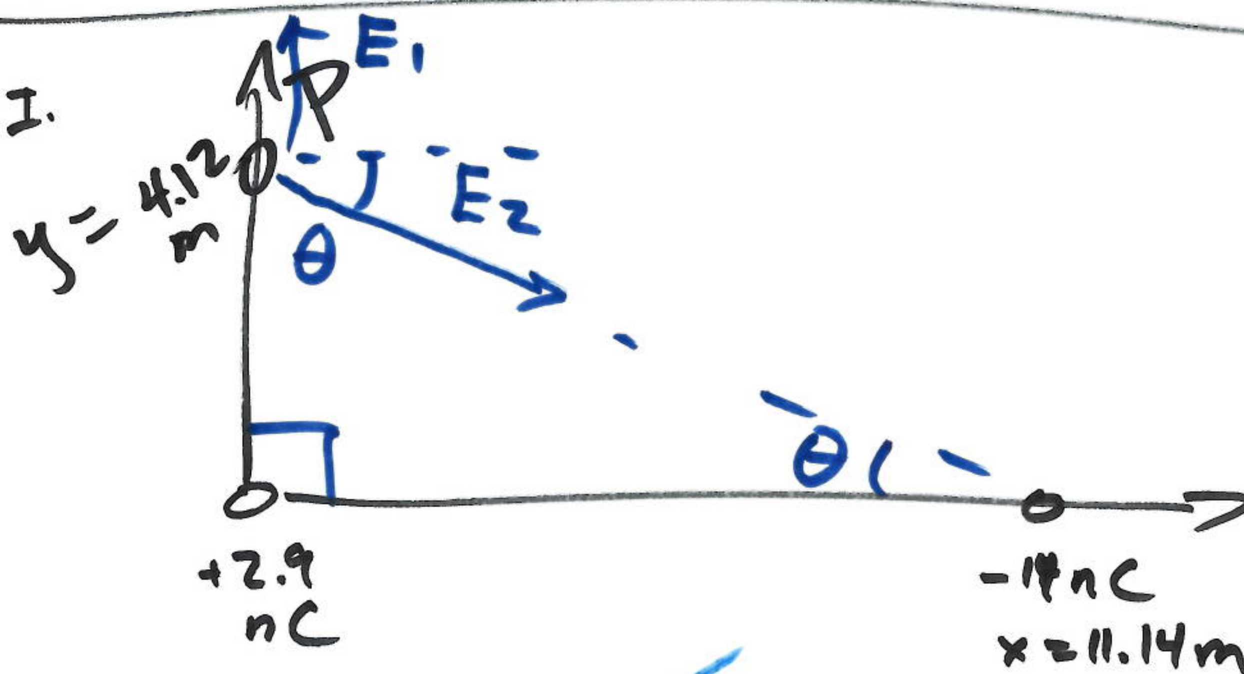
$$E = \frac{kQ}{r^2}$$

Today:

I. Quiz 1 Solution

II. RC Circuits: Be Amazed! Time-dependence

I.




$$E_1 = \frac{kQ}{r^2} = \frac{9\cancel{\times 10^9} \frac{Nm^2}{C^2} \cdot 2.9 \cancel{\times 10^{-9}} C}{(4.12m)^2}$$

$$E_1 = 1.54 \frac{N}{C}$$

$$E_2 = \frac{k Q_2}{r_2^2} = \frac{9 \times 10^9 \frac{Nm^2}{C^2} \times 14 \times 10^{-9} C}{(4.12m)^2 + (11.14m)^2}$$

$$E_2 = 0.893 \frac{N}{C}$$

$$\tan\theta = \frac{opp}{\cancel{hyp}\ adj.} = \frac{4.12m}{11.14m}$$

$$\theta = 20.3^\circ$$

$$E_{2x} = +E_2 \cos\theta = 0.893\tfrac{N}{C} \cos 20.3^\circ = 0.838 \frac{N}{C}$$

$$E_{2y} = -E_2 \sin\theta = -0.310 \frac{N}{C}$$

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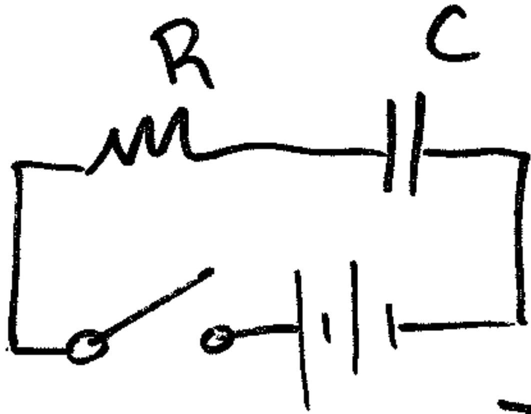
$$E_{Tot} = (0 + 0.838,\ 1.54 - 0.310) \frac{N}{C}$$
$$(E_{1x} + E_{2x},\ E_{1y} + E_{2y})$$

$$\boxed{E_{Tot} = (0.838,\ 1.23) \frac{N}{C}}$$

☆ Quiz Wed. on Gauss' Law ☆

## II. RC Circuits: how a DC Circuit can show time-dependance.




What is current, I, after switch closes? ($I(t)$)

Initially, C is <u>uncharged</u>.

loop rule:

$$V - I \cdot R - \overbrace{V_c}^{Q = CV_c} = 0$$

$$I = \frac{dQ}{dt} \quad \text{and} \quad Q = \int_0^t I(t)\,dt$$

$$V - \frac{dQ(t)}{dt} \cdot R - \frac{Q(t)}{C} = 0$$

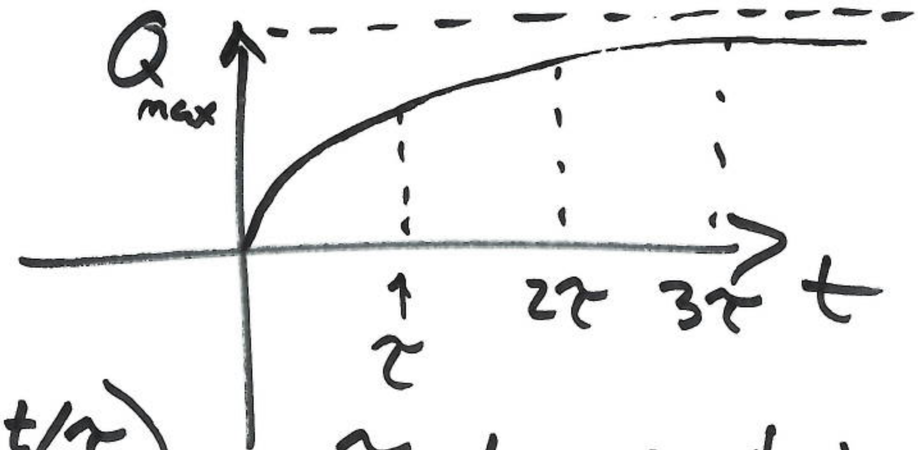
What is $Q(t) = ?$

Guess $Q(t)$ must contain $e^t$ ...

What is $Q(t=0)$ ? $= 0$

$\underset{max}{Q}(t \to \infty)$ ? Cap. is "full".

$$Q_{max} = V \cdot C$$




try:

$$Q(t) = Q_{max}\left(1 - e^{-t/\tau}\right)$$

$\tau$ = time constant

Plug into: $V - \frac{dQ}{dt} \cdot R - \frac{Q(t)}{C} = 0.$

$$\frac{dQ}{dt} = -Q_{max}\, e^{-t/\tau}\left(-\frac{1}{\tau}\right)$$

$$\frac{dQ}{dt} = \frac{Q_{max}}{\tau} e^{-t/\tau}$$

$$V - R\,\frac{Q_{max}}{\tau} e^{-t/\tau} - \frac{Q_{max}}{C}\left(1 - e^{-t/\tau}\right) = 0$$

$$\underbrace{V - \frac{Q_{max}}{C}}_{=0} \underbrace{- \frac{RQ_{max}}{\tau} e^{-t/\tau} + \frac{Q_{max}}{C} e^{-t/\tau}}_{=0} = 0$$

for any time:

Separately

$$CV = Q_{max}$$ ✓yes is right

$$\frac{\cancel{Q_{max}}}{C}\cancel{e^{-t/\tau}} - \frac{R\cancel{Q_{max}}}{\tau}\cancel{e^{-t/\tau}} = 0$$

$$\frac{1}{C} - \frac{R}{\tau} = 0 \qquad \frac{1}{C} = \frac{R}{\tau} \qquad \boxed{\tau = RC}$$

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$$I(t) = \frac{dQ}{dt} = \frac{Q_{max}}{\tau} e^{-t/\tau}$$

$$I(t) = \frac{CV}{RC} \cdot e^{-t/\tau} = \frac{V}{R} e^{-t/\tau}$$

<u>Note:</u>

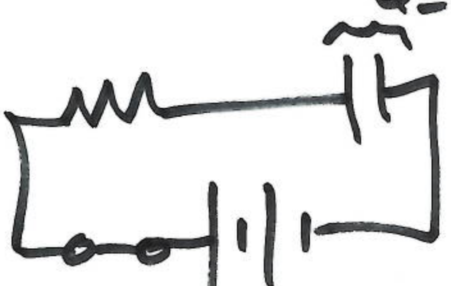
$I \to 0$ as $t \to \infty$

<u>and</u>

at $t=0$, $I = \frac{V}{R} \Rightarrow V = RI$ ✓true

at $t=0$, $C$ is empty $(Q=0)$ Thus $V_c = 0$

$Q=0 \Rightarrow$ wire



$t=0$

loop rule at $t=0$

$$V - IR - \cancel{V_c}^{\,0} = 0$$

$V = IR$ at $t=0$ ✓ true