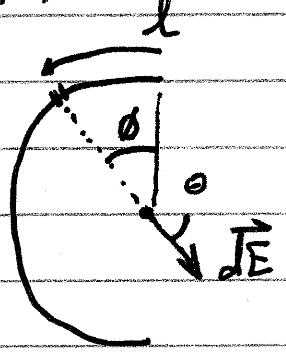
Phys 2426   2014-09-10

HW1 #9



Each bit of charge is

$$dq = \lambda\, d\ell$$

↑ Length of bit

The $\vec{E}$ due to the bit is:

$$dE = \frac{k\,dq}{r^2} \quad \text{(away)}$$

The x-component of $\vec{dE}$ is $dE\cos\theta$.
But how is θ related to ℓ?

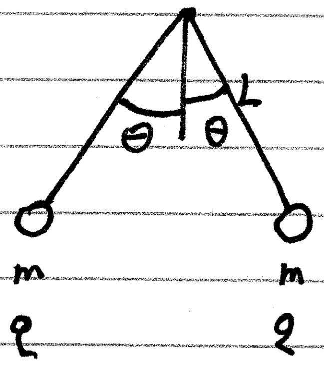
$\ell = R\phi$ From angle geometry $\theta + \phi = \frac{\pi}{2}$
So, $\cos\theta = \sin\phi = \sin(\ell/R)$

$$E_x = \int dE_x = \int dE\cos\theta = \int \frac{k\lambda\, d\ell}{R^2}\sin\left(\ell/R\right)$$

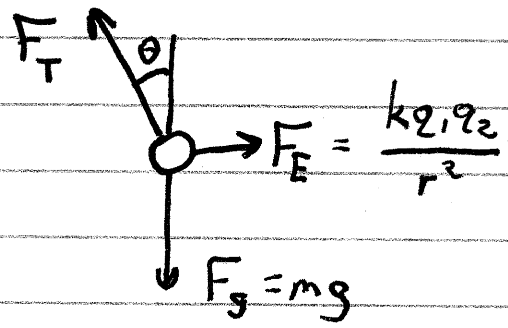
$$\int \sin\left(\frac{\ell}{R}\right) d\ell = -\cos\left(\frac{\ell}{R}\right)R$$

Limits of integration? $\ell = 0 \ldots \pi R$
Charge Density $\lambda = Q/L$

②



Forces on one object:



Total Force = 0

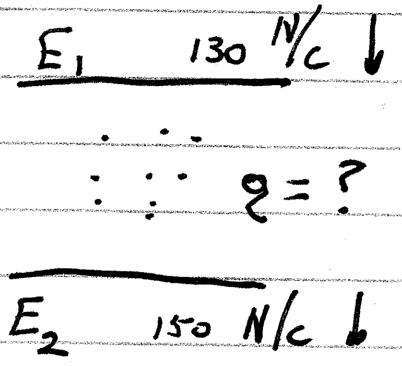
	x	y
F_E	kq^2/r^2	0
F_g	0	$-mg$
F_T	$-F_T\sin\theta$	$F_T\cos\theta$
Total	0	0

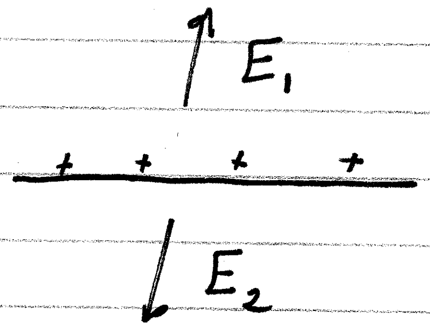
$$F_T\cos\theta - mg = 0 \quad \rightarrow \quad F_T = \sim$$

$$kq^2/r^2 - F_T\sin\theta = 0 \quad \rightarrow \quad r = \sim$$

③

HW1 #13





$$E = \frac{\sigma}{2\varepsilon_0}$$

How is ρ related to σ?
Charge in a rectangular block is:

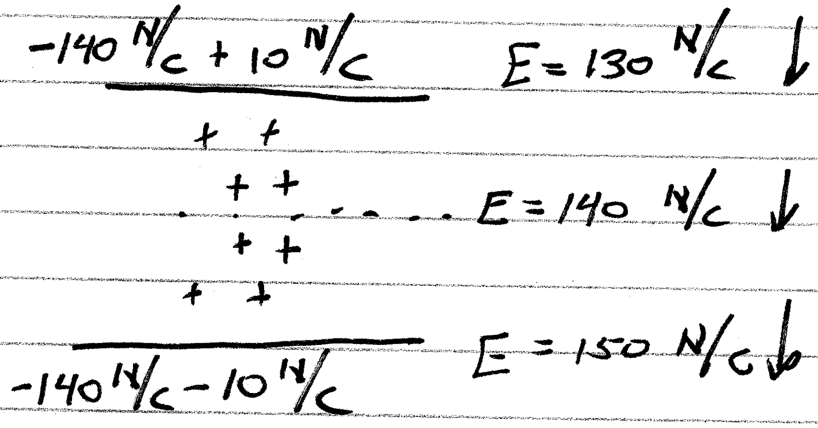
$$\boxed{E_1 - E_2 = \frac{\sigma}{\varepsilon_0}}$$

$$Q = \rho(Vol) = \rho A h$$

└ height
└ Area of base

$$Q = \sigma A$$

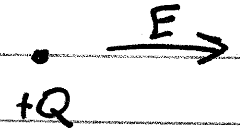
Compare: $\rho h = \sigma$



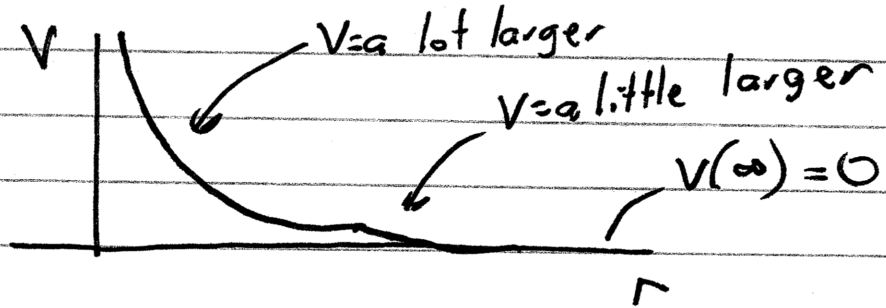
$$\frac{\sigma}{2\varepsilon_0} = 10 \text{ N/C}$$

Capacitors and Storing Charge

Point Charge



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

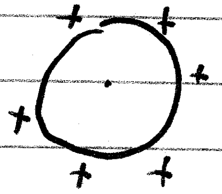


Since $E = -\text{Slope of } V \text{ vs } r$

$$V = -\int E\, dr$$

$$V(r=r_1) - V(r=r_2) = -\int_{r_1}^{r_2} E\, dr$$

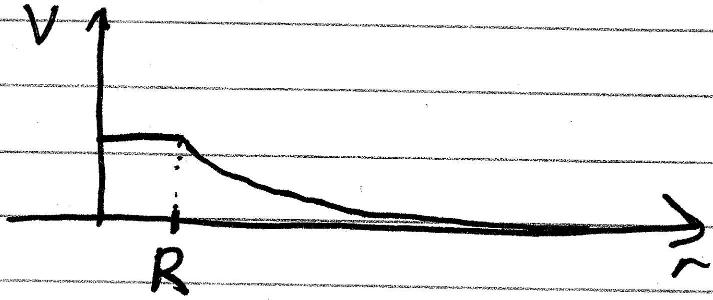
Metal Ball



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

(if r = outside) (r=outside)

E=0 (inside)



Voltage of a charged metal ball

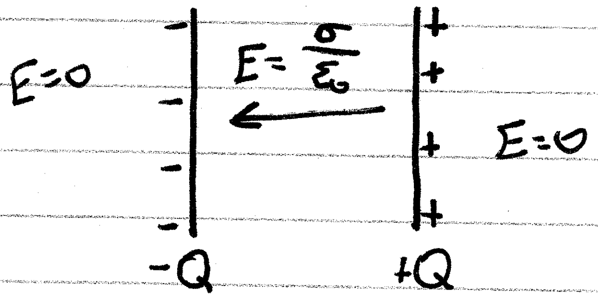
$$V = \frac{kQ}{R}$$

If I have 1 V of "pressure", how much Q will go onto the ball? $R = 0.1\ \text{m}$

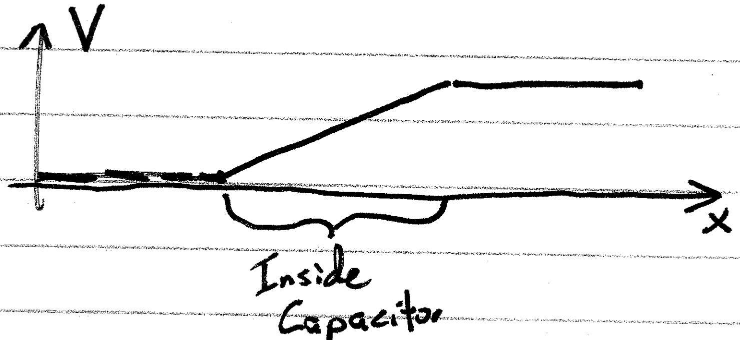
$$Q = \frac{R}{k} V = \frac{(0.1\ \text{m})}{\left(9\times10^{9}\ \frac{\text{Nm}^2}{\text{C}^2}\right)} (1\ \text{V})$$

$$= 1.1\times10^{-11}\ \text{C} = 11.1\times10^{-12}\ \text{C} = 11\ \text{pC}$$

A capacitor has two charge-storing plates.



The total charge is always zero.



$$E = \frac{\text{rise}}{\text{run}} = \frac{\Delta V}{d}$$

$$\Delta V = Ed = \frac{\sigma d}{\varepsilon_0}$$

$$\Delta V = \frac{Q\,d}{A\,\varepsilon_0}$$

$$Q = \left(\frac{\varepsilon_0 A}{d}\right) V$$

$A = 0.3\ \text{m}^2 \qquad d = 0.0001\ \text{m}$

$\varepsilon_0 = 8.85\times10^{-12}\ \text{C}^2/\text{Nm}^2$

$Q = 2.7\times10^{-8}\ \text{C}$

$= 27\ \text{nC}$

⑥

Capacitor Eqns

$Q = CV$ C= capacitance in farads (F)

$\text{Energy} = \frac{1}{2}QV$

$C = \frac{\varepsilon_0 A}{d}$ Air-Filled Cap

$C = K \frac{\varepsilon_0 A}{d}$

$\uparrow$ Kappa = dielectric constant