Physics 114, February 5, 2015

Note Title 2/1/2010

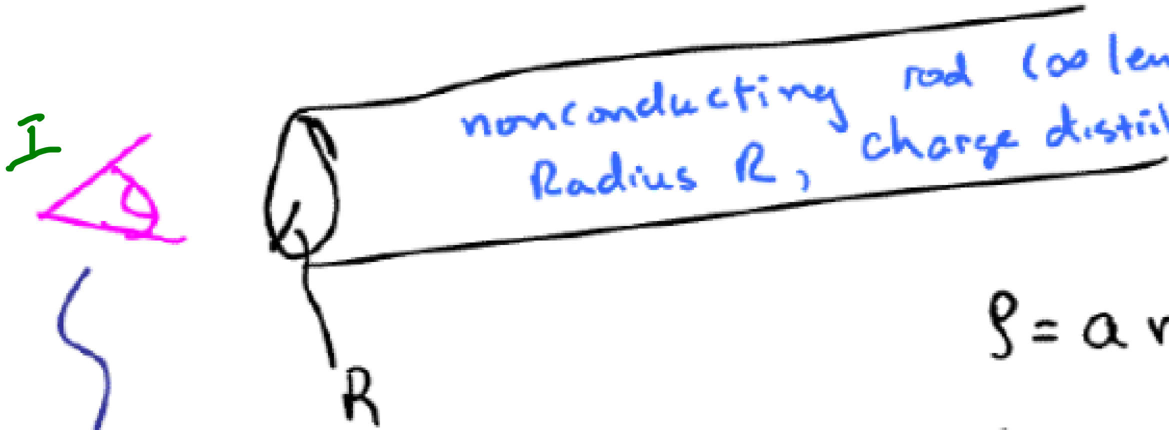
1

- Exam 1 - Feb. 12
  Hoyt
  Normal Lecture time

- Will cover [Material thru end of Gauss' law today
  Workshops 1+2
  Prob sets 1-3
  Chapters 21, 22]

- "Cheat sheet" 1 side 8.5 x 11 inch sheet
  (NOT topologically enhanced !!)
- Scientific calculator (MUST show work)
- Pen
- Previous exams available for study/review
- P.S. 4 due 2/13
  will be quite short due to Thursday exam

Last little Gauss' law example

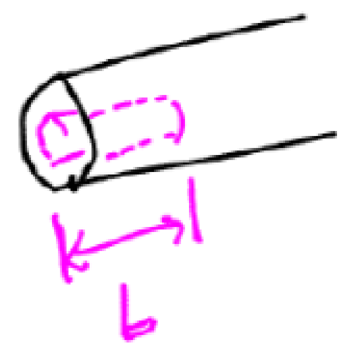


noncondacting rod (∞ length) Radius R, charge distributed as $\rho = ar$ for $r<R$

$\rho = ar \qquad r<R$

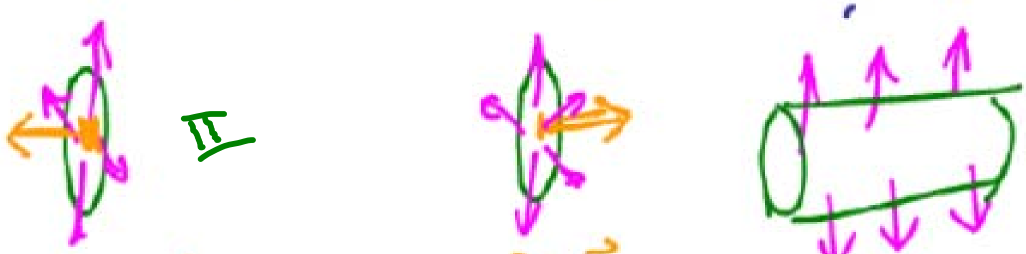
Total chg/length of $+\lambda$

what is $\vec{E}$ for $r<R$



$$\oint \vec{E}\cdot\vec{dA} = \frac{Q_{encl}}{\epsilon_0}$$

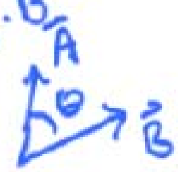
I $$\int_{\text{endcap 1}} \vec{E}\cdot d\vec{A} + \int_{\text{endcap 2}} \vec{E}\cdot d\vec{A} + \int_{\text{pipe}} \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$



II $\vec{E}\cdot d\vec{A} = 0$ $\quad$ $\vec{E}\cdot d\vec{A} = 0$ $\quad$ III

$\downarrow$

Recall $\vec{A}\cdot\vec{B} = |\vec{A}||\vec{B}|\cos\theta$



IV $$|\vec{E}|\int_{\text{pipe surf}} dA = |\vec{E}|\, 2\pi r L = \frac{Q_{encl}}{\epsilon_0}$$

over volume of Gaussian surface

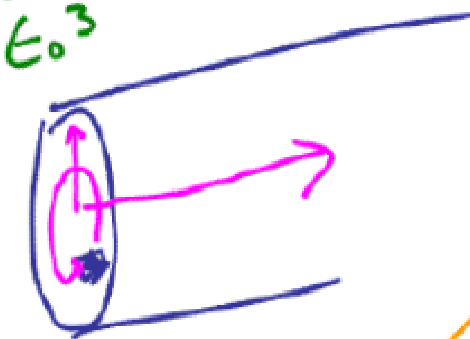
V $$|\vec{E}|\, 2\pi r L = \frac{\int \rho\, dv}{\epsilon_0} = \frac{\int \rho \overbrace{[2\pi r L\, dr]}^{dv}}{\epsilon_0} = \frac{2\pi L}{\epsilon_0}\int_0^r a r^2\, dr$$

I

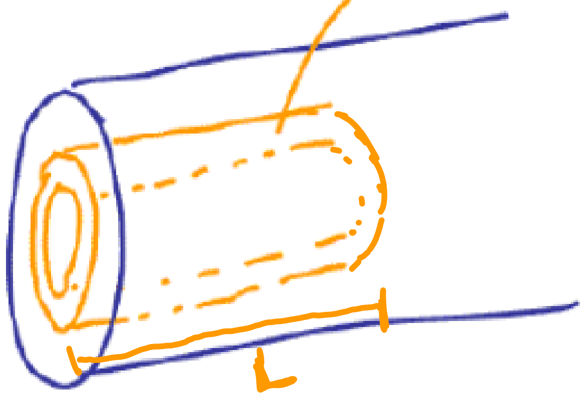
$$|\vec{E}|\,2\pi r L = \frac{2\pi L a r^3}{\epsilon_0 \, 3}$$

II

$$|\vec{E}| = \frac{a r^2}{\epsilon_0 3} \text{ out radially}$$



$$dv = 2\pi r L\, dr$$ III

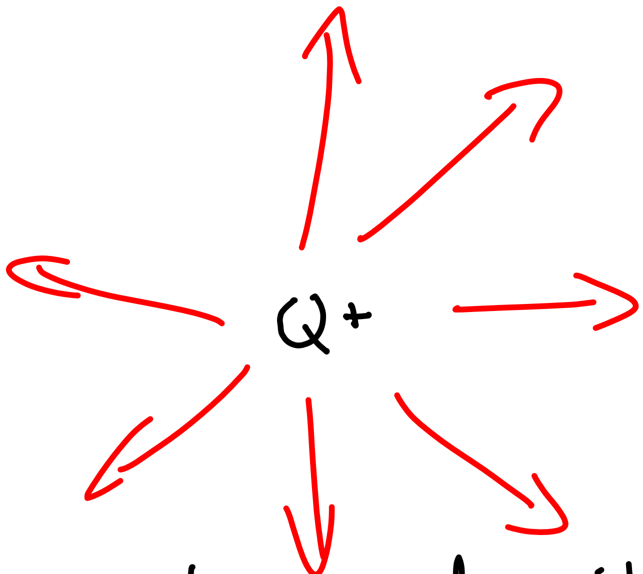


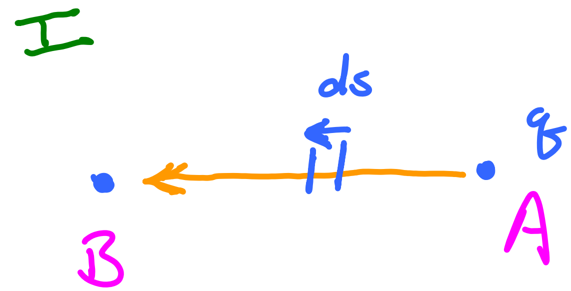
$$|\vec{E}| = \frac{a r^2}{\epsilon_0 3}$$

$$\vec{E} = \frac{a r^2}{\epsilon_0 3}\ \widehat{\text{radial}} \quad \text{for } r < R$$

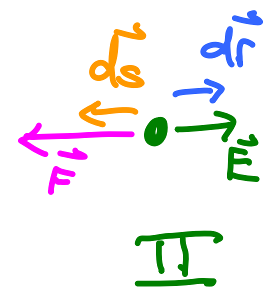
$$\boxed{\text{End of material for Exam 1}}$$

Energy and Potential in electrostatics





How much work does it take me to move q from pt. A to pt. B



III

$$W=\int_A^B \vec F\cdot d\vec s = \int_A^B F\,ds = \int_A^B qE\,ds = -\int_{r_A}^{r_B} qE\,dr$$

$\vec F, d\vec s$ in same direction

$ds = -dr$

7

I

$$-\int_{r_A}^{r_B} \frac{qQk}{r^2}\,dr = kqQ\left[\frac{1}{r}\right]_{r_A}^{r_B} = kqQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

NeT (+) since $r_A > r_B$

II

$$W_{A\to B} = \frac{qQk}{r_B} - \frac{qQk}{r_A}$$

should be positive
I am putting work into the system

III

$$\frac{W}{q} = kQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right] \equiv \text{Potential Difference bet } A + B$$

$$\Delta V = V_B - V_A = V_{AB} \equiv \text{Potential Difference}$$

$$1 \text{ Volt} = 1 \text{ Joule}/\text{Coulomb}$$

Man of the Hour

hopefully this man
didn't go thru his whole life
this pissed off

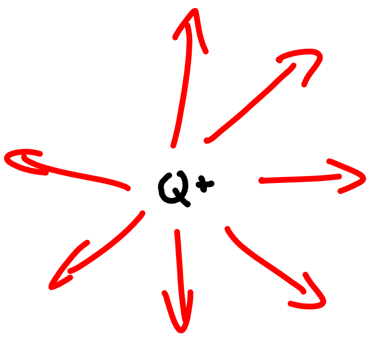
1 Volt = 1 Joule/Coulomb

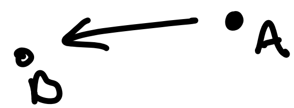
Count Alessandro Giuseppe
Antonio Anastasio Volta

Como, Lombardy, Italy

1745 – 1827

Invented the Voltaic pile
forerunner of the
modern battery





I

$$V_{AB} = kQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

Define the (Absolute) potential to be zero at $r \to \infty$

$r_A \to \infty$

II

$$V(r) = \frac{kQ}{r}$$

Potential of a Point charge

Electrostatics (Electromagnetism) is a Conservative force

$\Downarrow$

Potential difference is Path independent

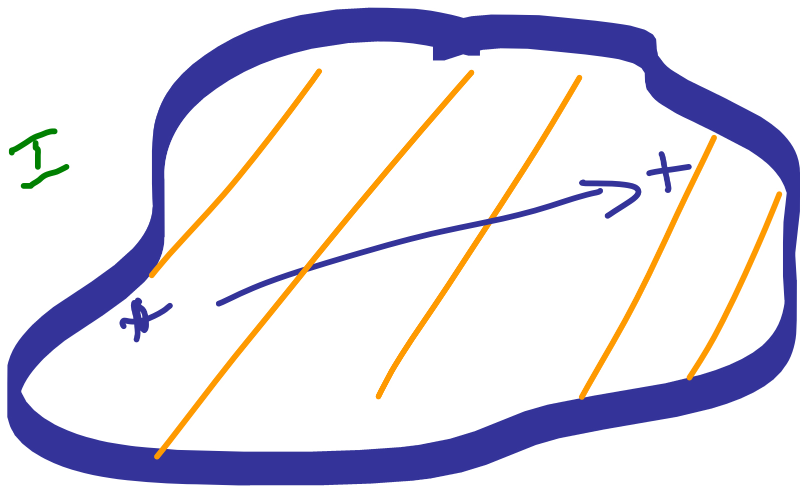
Point charge

$$Q \xrightarrow{\vec{r}} \bullet p$$

$$\boxed{V_p = \frac{kQ}{r}}$$

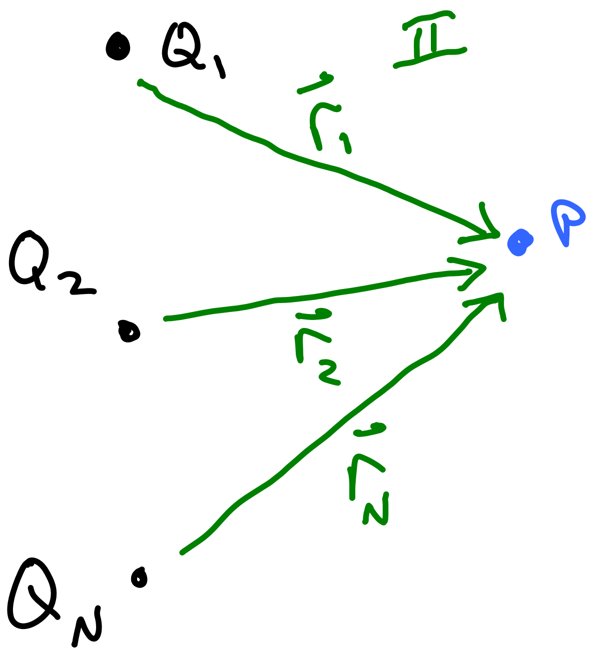
Note this is a scaler

I



Conductor is at an "equipotential"

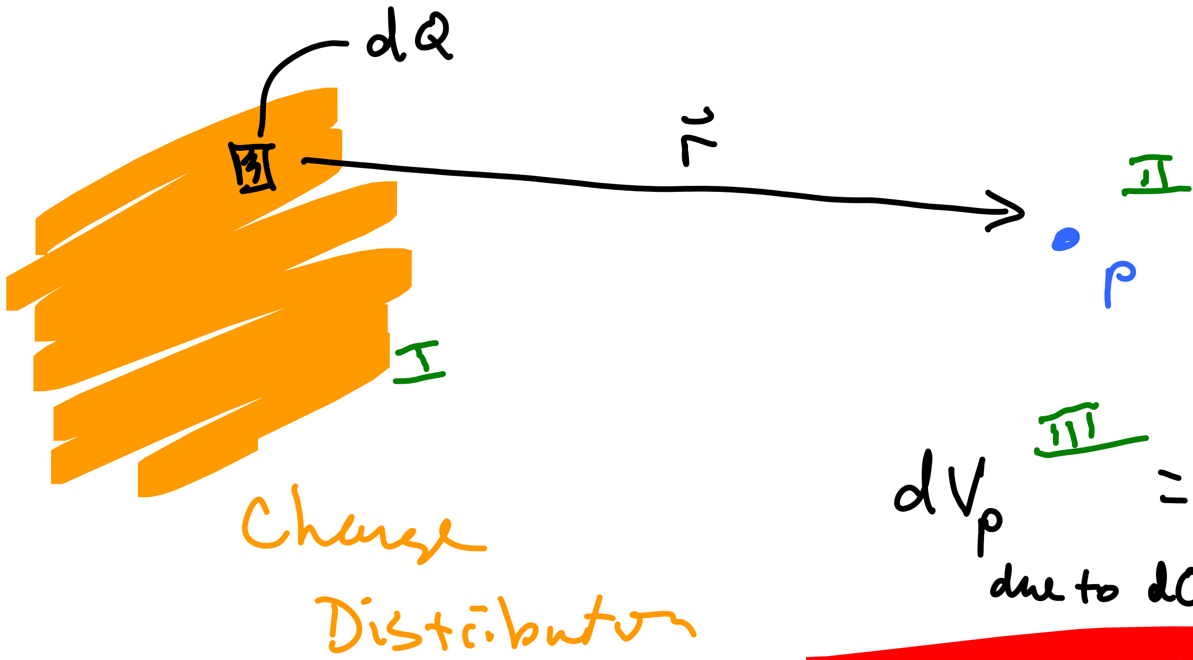
equipotential surface



$$\boxed{V_P = \sum_{i=1}^{N} V_i = \sum_{i=1}^{N} \frac{kQ_i}{r_i}}$$

III

Potential for a system of discrete charges



III

$$dV_{p\,\text{due to } dQ} = \frac{k\,dQ}{r}$$

potential at P due to charge distribution

$$\boxed{V_p = \int_{vol} \frac{k\,dQ}{r}}$$

IV

r is Not squared
Not a vector

easy relative to $\vec{E}$ calcs

13

I

$$V = \frac{W}{q}$$

II

$$dV = \frac{dW}{q} = \frac{-\vec{F}\cdot\vec{ds}}{q} = -\vec{E}\cdot\vec{ds}$$

III

$$dV = -E_s\,ds$$

$$E_s = -\frac{dV}{ds}$$

Why do you care??

$$E_s = -\frac{dV}{ds}$$

can get $\vec{E}$ from V

$$V(x) \longrightarrow E_x = -\frac{dV}{dx}$$

$V(x,y,z)$

$$\vec{E} = \hat{i}E_x + \hat{j}E_y + \hat{k}E_z$$

$$\vec{E} = \hat{i}\left(-\frac{dV}{dx}\right) + \hat{j}\left(-\frac{dV}{dy}\right) + \hat{k}\left(-\frac{dV}{dz}\right)$$

No worries for P114

$$\frac{\partial V}{\partial s} = \frac{dV}{ds}$$ where all other variables are treated as constant

15

$$\vec{E} = \hat{i}\left(-\frac{\partial V}{\partial x}\right) + \hat{j}\left(-\frac{\partial V}{\partial y}\right) + \hat{k}\left(-\frac{\partial V}{\partial z}\right)$$

$$\vec{E} \equiv -\vec{\nabla} V = -\overrightarrow{\text{grad}}\, V$$

$$\vec{\nabla} \equiv \text{gradient} \equiv \hat{i}\frac{\partial}{\partial x} + \hat{j}\frac{\partial}{\partial y} + \hat{k}\frac{\partial}{\partial z}$$

Vector operator

$$V = f(x,y,z) = e^{x} y^{2} z^{3}$$

$$\vec{E} = -e^{x} y^{2} z^{3}\,\hat{i} - 2y e^{x} z^{3}\,\hat{j} - 3z^{2} e^{x} y^{2}\,\hat{k}$$

Example in 3 dimensions

Deposit Q

How does it get distributed?

2 conducting spheres
connected by conducting wire

Deposit Q

How does it get distributed?

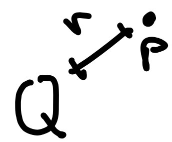
2 conducting spheres connected by conducting wire

System is at equipotential

$$\frac{kQ_1}{R_1} = \frac{kQ_2}{R_2}$$

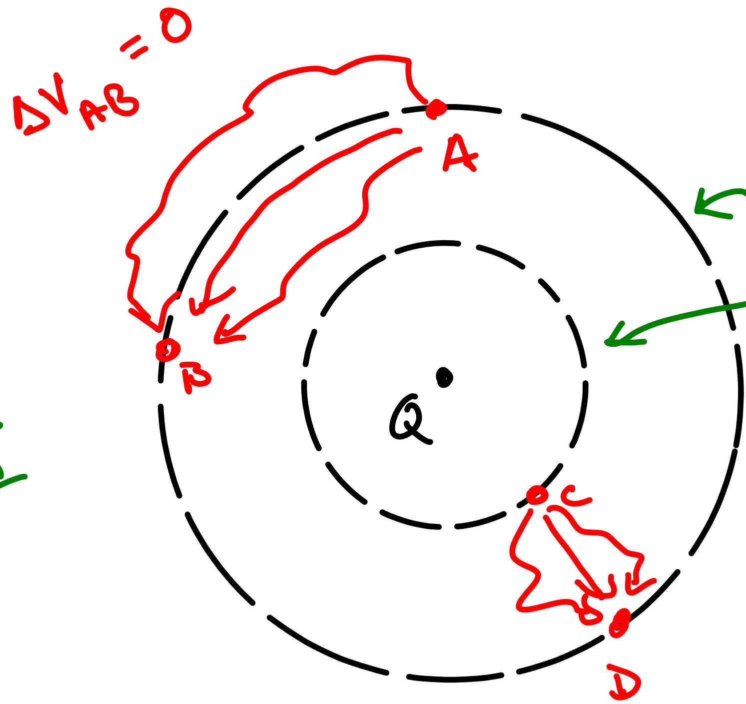
$Q_1 : Q_2$ as $R_1 : R_2$

I



$$V_p = \frac{kQ}{r}$$

II



lines of equal potential

Equipotential lines

$$\Delta V_{CD} = \frac{kQ}{r_D} - \frac{kQ}{r_C}$$

Equipotential lines always at right ∠'s to electric Field