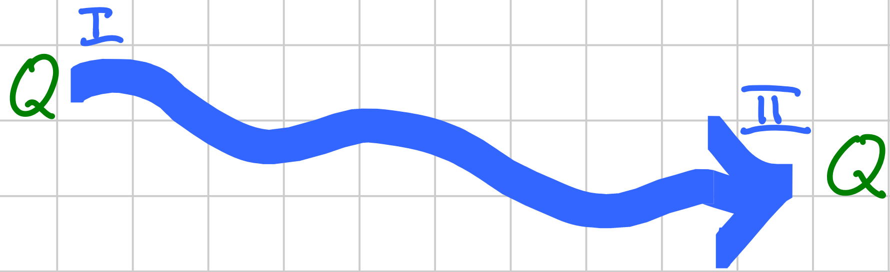
Physics 142 - September 23, 2010

Note Title 9/23/2008

- How did Thurs. "Lecture" Work out?

- Exam I - Oct 7 0800-0920 Loc TBA
  NOT Oct 2 during class time
  - Calculators
  - 1 3x5 index card (both sides) formulas
  - Past P142 exams
  - formula sheet + integral tables supplied
  - Material coverage forthcoming

Last time



$\frac{\text{work}}{\text{charge}}$ to move Q from I $\rightarrow$ II is potential difference

Δ Energy of system $\equiv \Delta U$

$$\frac{W}{q} = -\frac{\Delta U}{q} \equiv \text{Potential difference}$$

well defined

Absolute potential requires that a "zero" be defined

V or ΔV or $V_{\text{I II}}$ or $V_{\text{II}} - V_{\text{I}}$

units $\rightarrow$ Joules/Coulomb

Man of the Hour

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

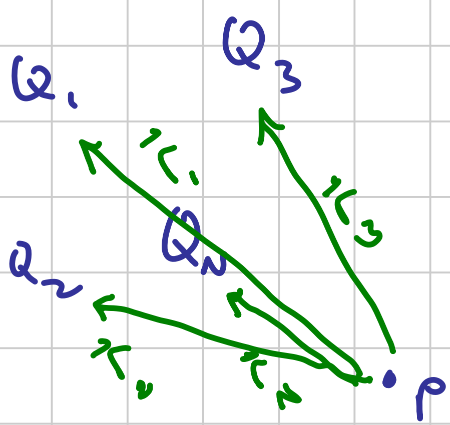
hopefully this man didn't go thru his whole life this pissed off

$$\boxed{\begin{array}{c}\text{Electrostatics (Electromagnetism)} \\ \text{is a Conservative force} \\ \Downarrow \\ \text{Potential difference is Path independent}\end{array}}$$

Point charge

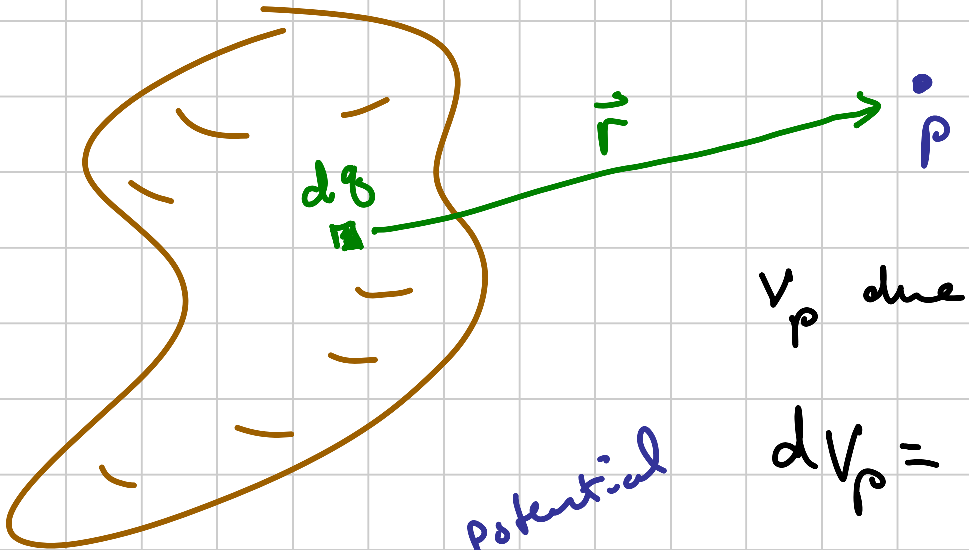
$$Q \xrightarrow{\vec{r}} \cdot P \qquad \boxed{V_P = \frac{kQ}{r}}$$

Note this is a scaler



$$\boxed{V_P = \sum_i \frac{kQ_i}{r_i}}$$

Potential of sum is scalar sum of potentials



V_p due dq

$$dV_p = \frac{k\, dq}{r}$$

potential

$$V_p = \int_{\text{volume}} \frac{k\, dq}{r}$$

$\rho\, dV$

volume

Why do you care??

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

can get $\vec{E}$ from V.

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

$V(x,y,z)$

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

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

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

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

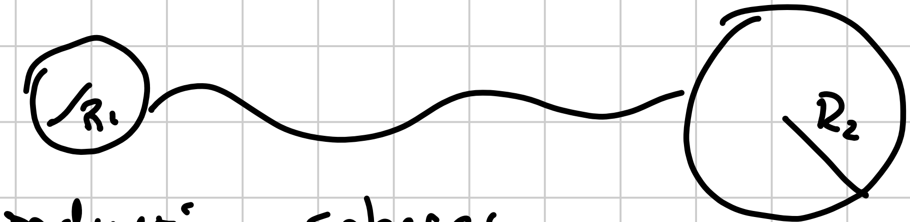
$$\vec{E} \equiv -\vec{\nabla} V = -\vec{\text{grad}}\, V$$

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

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

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

Vector operator



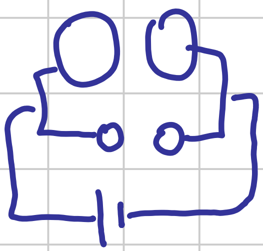
Deposit Q

How does it get distributed?

2 conducting spheres connected by conducting wire

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

$Q_1 : Q_2$ as $R_1 : R_2$

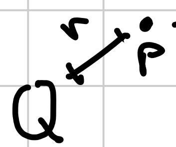


where does breakdown occur?

$$E_1 = \frac{kQ_1}{R_1^2}$$

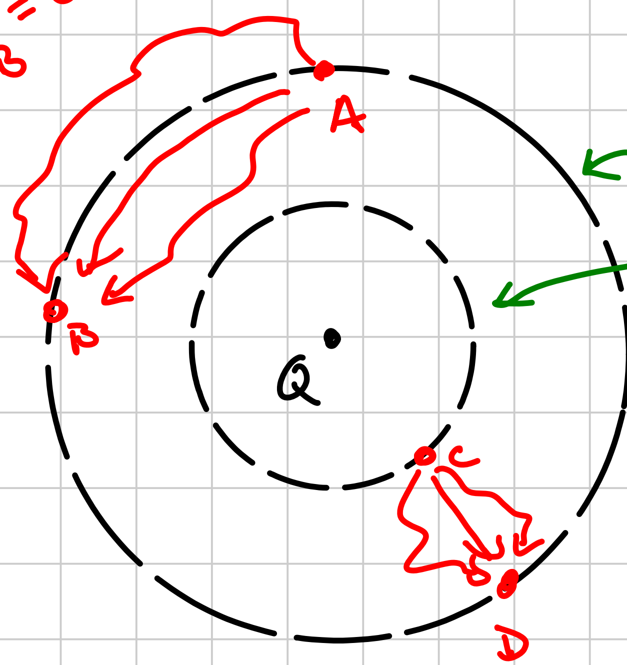
$$E_2 = \frac{kQ_2}{R_2^2}$$

E_1	E_2
$\frac{kQ_1}{R_1^2}$	$\frac{kQ_2}{R_2^2}$
$\frac{kQ_1}{R_1} \frac{1}{R_1}$	$\frac{kQ_2}{R_2} \frac{1}{R_2}$



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

$\Delta V_{AB} = 0$

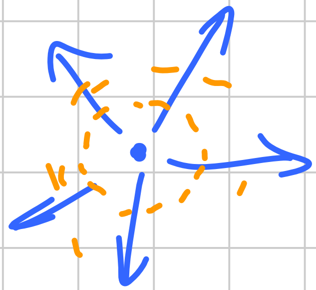


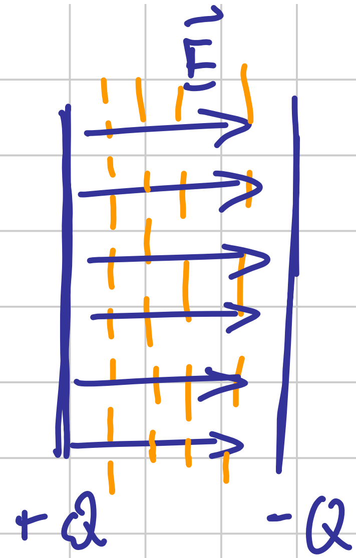
lines of equal potential

Equipotential lines

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

Equipotential lines always at right ∠es to electric field

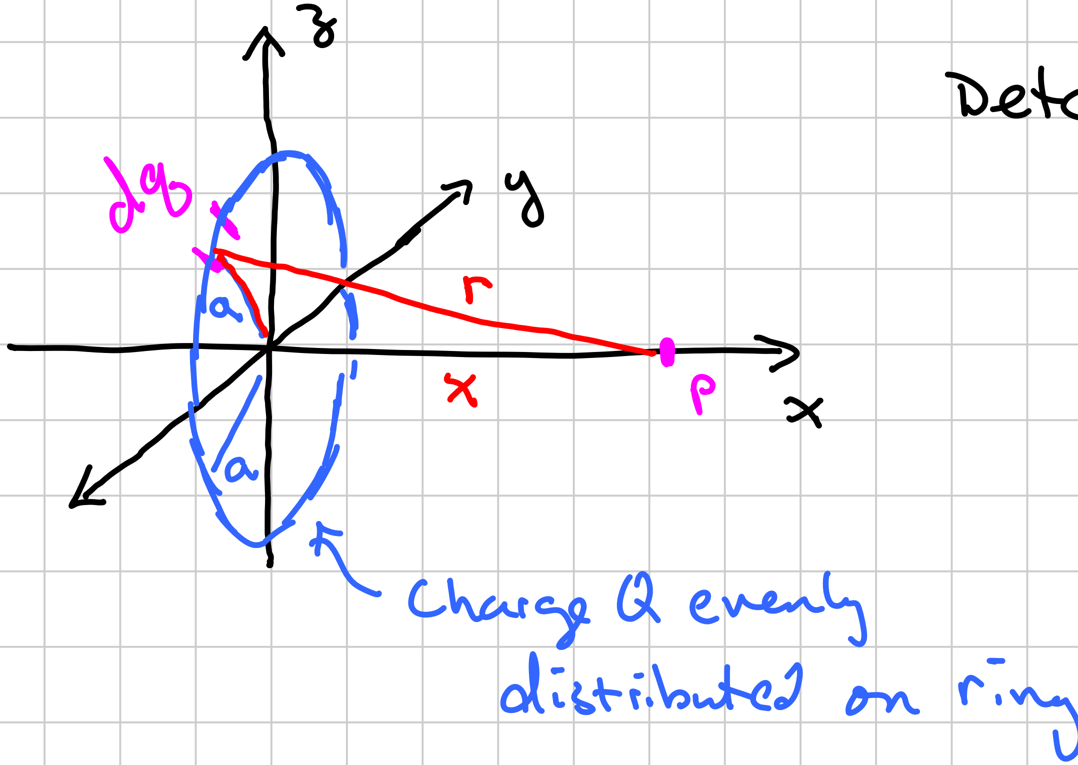




- - - - Lines of equipotential

↳ Always at Right Angles to electric field lines

(Recall $\vec{E} = -\vec{\nabla} V$ ... meaning the gradient or direction of greatest slope in Potential function)

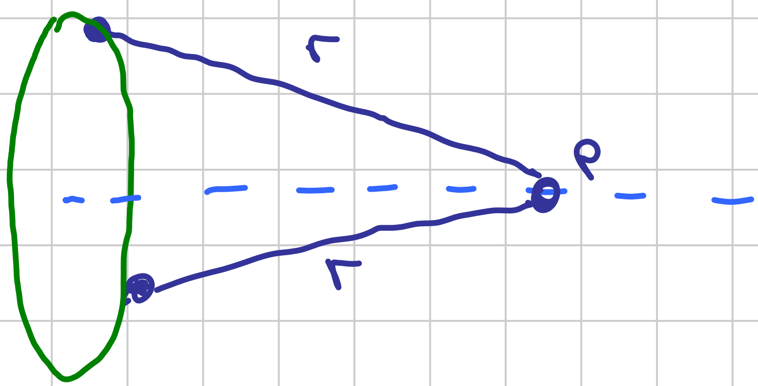


Determine V_P and $\vec{E}_P$

$$dq = \lambda\, ds$$

$$\lambda = \frac{Q}{2\pi a}$$

$$r = \sqrt{x^2 + a^2}$$



$$V_P = \int_{\text{ring}} \frac{k\, dq}{r}$$

$$V_P = \frac{k}{r}\int \lambda\, ds = \frac{k\lambda\, 2\pi a}{r}$$

$$V_p = k\frac{Q}{2\pi a}\frac{2\pi a}{\sqrt{a^2+x^2}} = \frac{kQ}{\sqrt{a^2+x^2}}$$

as $x \to \infty$ $V_p \to \frac{kQ}{x}$ (looks like point charge from distance)

$$\vec{E}_p = -\nabla V = -\frac{d}{dx}\frac{kQ}{\sqrt{a^2+x^2}}\hat{x} = \frac{kQx}{(a^2+x^2)^{3/2}}\hat{x}$$

as $x \to \infty$ $\vec{E} \to \frac{kQ}{x^2}\hat{x}$

Field of a point charge

✓