Physics 142 - September 20, 2005

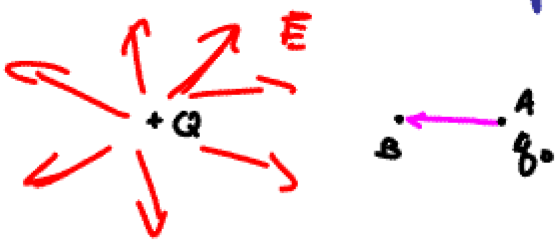
Electric Potential

Project - show skateboarding video

Last time -

- review of curvilinear coordinates and scale factors that come into integrations

- Gauss' Law, cylindrical example
- Start of electric potential



$$W = \int_A^B \vec{F} \cdot d\vec{s} = -\int q_0 \vec{E} \cdot d\vec{s} = -\int_A^B q_0 E\,dr$$

$$W = -q_0 Q k \int_A^B \frac{1}{r^2} dr = k q_0 Q \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

Important

$$\boxed{\frac{\text{Work}}{q_0} \equiv \text{Potential difference}}$$

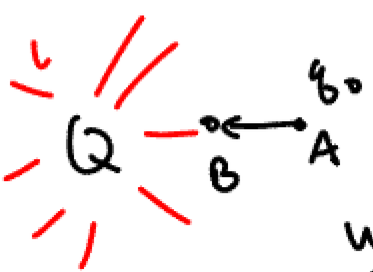
$$\Delta V = V_B - V_A = V_{AB}$$

Δ in potential energy $\equiv$ work

$$\text{Potential Diff} \equiv \frac{\Delta PE}{q_0}$$

"is defined as"

can define "zero" of potential

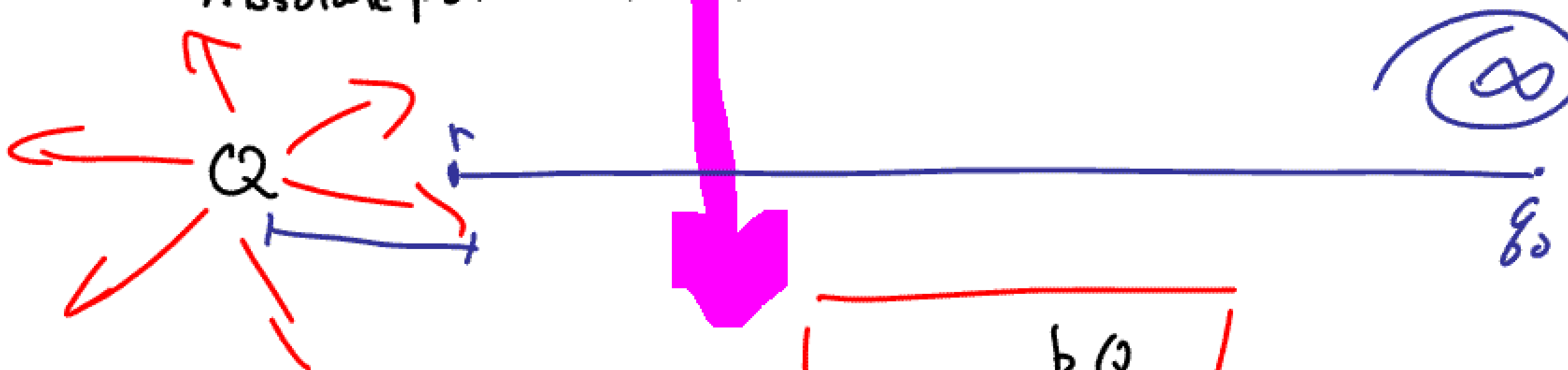


Allows us to have Absolute system of potential

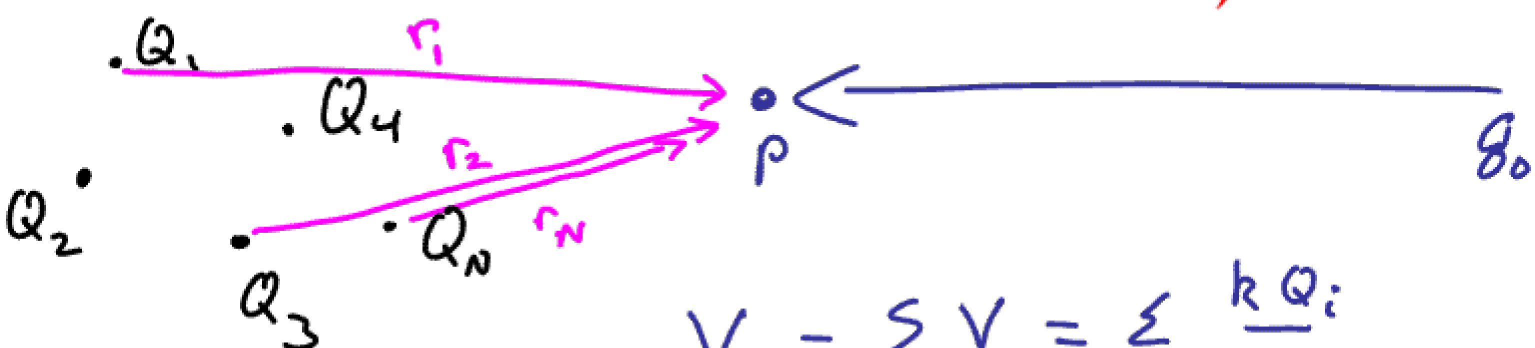
$$W/q_0 = \boxed{kQ\left[\frac{1}{r_B} - \frac{1}{r_A}\right]}$$

define potential to be zero at $r \to \infty$

Absolute potential at r



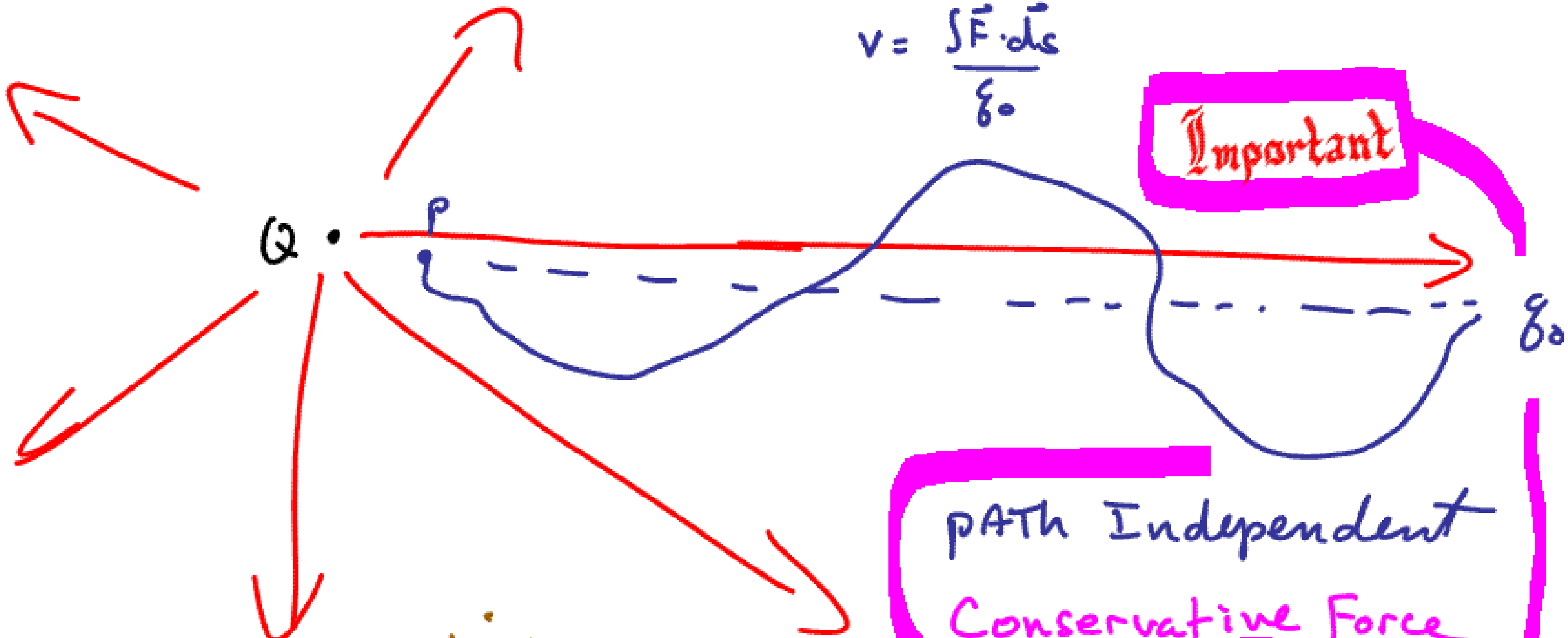
Potential at r = $\boxed{V(r) = \frac{kQ}{r}}$ Important



$$V_P = \sum_N V_i = \sum_N \frac{kQ_i}{r_i}$$

$$V = \frac{\int \vec{F} \cdot d\vec{s}}{q_0}$$

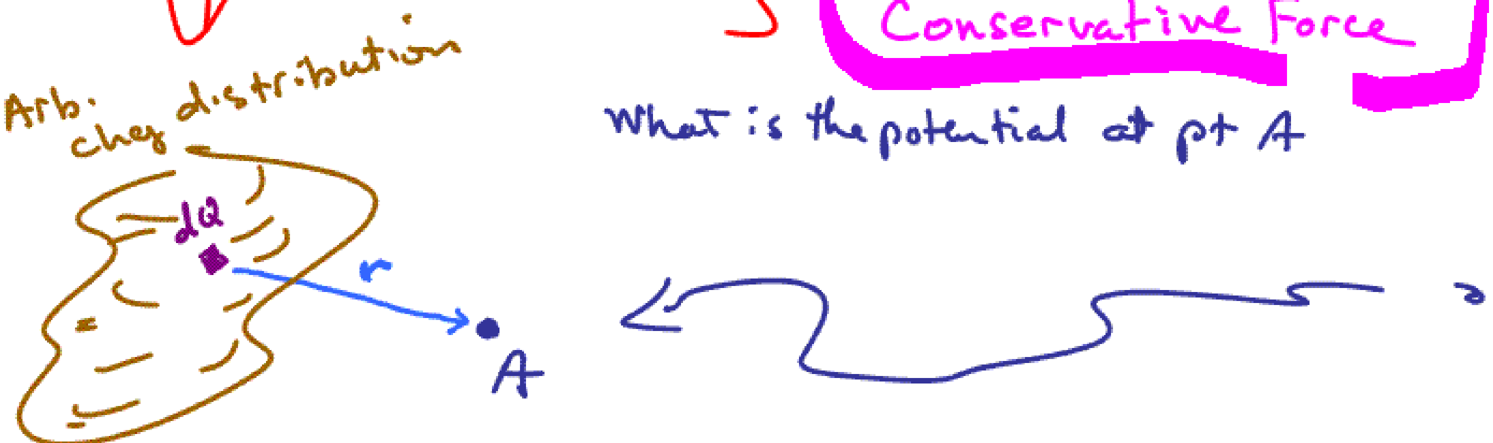
Important



PATH Independent

Conservative Force

What is the potential at pt A



$$V_A \text{ due to } dQ = dV_A = \frac{k\,dQ}{r}$$

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

Important

$$V = \frac{W}{q_0} \qquad dV = \frac{dW}{q_0} = -\vec{E}\cdot\vec{ds} = -E_s\, ds$$

Component of E in S direction

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

often work in 3d

$V(x,y,z)$ to get $\vec{E}$ we need E_x, E_y, E_z

~~$E_x = -\frac{dV}{dx}$, $E_y = -\frac{dV}{dy}$, $E_z = -\frac{dV}{dz}$~~

$$E_x = -\frac{\partial V}{\partial x} \equiv \text{partial derivative of } V \text{ w res. to } x$$

$$\frac{\partial f}{\partial x} = \frac{dF}{dx}$$ Hold all other variables constant

$$E_y = -\frac{\partial V}{\partial y}, \qquad E_z = -\frac{\partial V}{\partial z}$$

The vector operator $\vec{\nabla}$ is called "del"

$$\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$$

$$\boxed{\vec{E} = -\vec{\nabla} V = -\overrightarrow{\mathrm{grad}}(V)}$$

Important

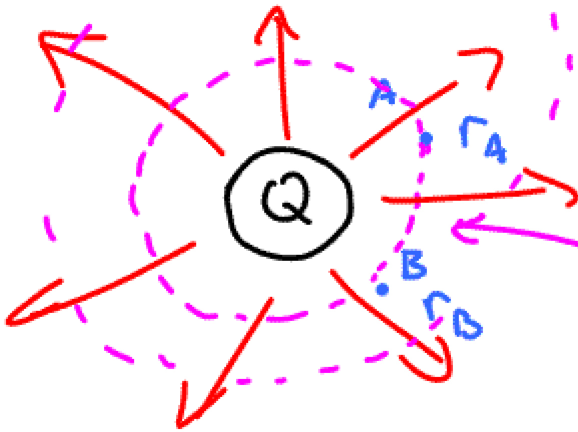
$\vec{\nabla} \equiv \mathrm{grad} \equiv$ gradient   3d vector operator

$$= \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}\hat{j} + \frac{\partial}{\partial z}\hat{k}$$

often it is easier to calculate the potential than $\vec{E}$ directly. Then use $\vec{E} = -\vec{\nabla} V$ to find $\vec{E}$

if 1d

$$E_r = -\frac{dV(r)}{dr}$$



$r_A = r_B \Rightarrow V_A = V_B$

pts all at same potential

Equipotential surface