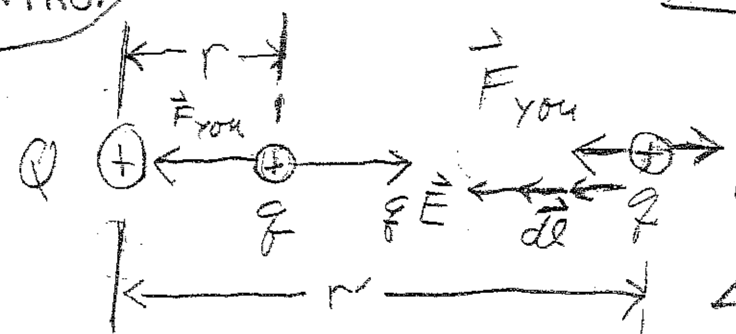
2-26-14 PHYSICS 4B

Appendix TO 2-12-14 supplement on CH. 23 INTRO. → **Potential Energy of a point CHARGE Q:**



$$|\vec{E}| = \frac{kQ}{r'^2}$$

$\Delta U = W_{you} =$ YOUR WORK

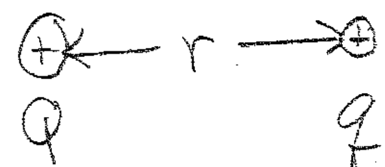
$$\Delta U = \int_{\infty}^{r} \vec{F}_{you} \cdot \vec{dl} \overset{*}{=} -\int_{\infty}^{r} \frac{kqQ}{r'^2} \cdot dr' = \frac{kqQ}{r} - \frac{kqQ}{\infty}$$

NOTE:
$\vec{F}_{you} \cdot \vec{dl}$
$= F_{you}\, dl \cos 0$
$= \frac{kqQ}{r'^2} \cdot dl$

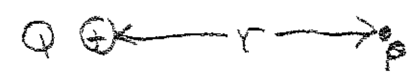
$$\Delta U = U(r) - U(\infty) = \frac{kqQ}{r} - \frac{kqQ}{\infty}$$

$$\Longrightarrow U(r) = \frac{kqQ}{r}; \quad U(\infty) \equiv 0.$$

*NOTE: $dl = |\vec{dl}| = -dr'$ since $dr' < 0$ as r' decreases during integral.



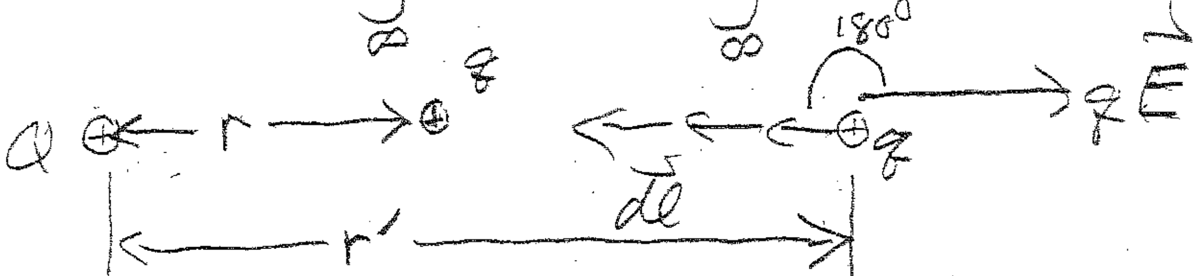
NOTE: potential $= V(r) = \frac{U(r)}{q} = \frac{kQ}{r}$ at POINT P SHOWN.



Note: alternative derivation using:

$\Delta U = -W$ where W = work by field: $\vec{F}$ = field force $= q\vec{E}$.

$$\Delta U = -\int_{\infty}^{r} \vec{F}\cdot \vec{dl} = -\int_{\infty}^{r} q\vec{E}\cdot\vec{dl}$$



Note: $\vec{E}\cdot\vec{dl} = E\cdot dl \cdot \cos 180^{\circ} = -E\,dl$

and $dl = -dr'$ since $dr' < 0$ because r' decreases during integral: $-E\,dl = -E\cdot(-dr') = E\,dr'$

$$\rightarrow \Delta U = -W = -\int_{\infty}^{r} qE\,dr' = -\int_{\infty}^{r} q\frac{kQ}{r'^2}\cdot dr' = \frac{kqQ}{r}$$

$$\Delta U = U(r) - U(\infty) = \frac{kqQ}{r}; \quad U(\infty) \equiv 0.$$

Assuming $U(\infty) = 0$ then $U(r) = \frac{kqQ}{r}$ and $V(r) = \frac{kQ}{r}$