

Potential

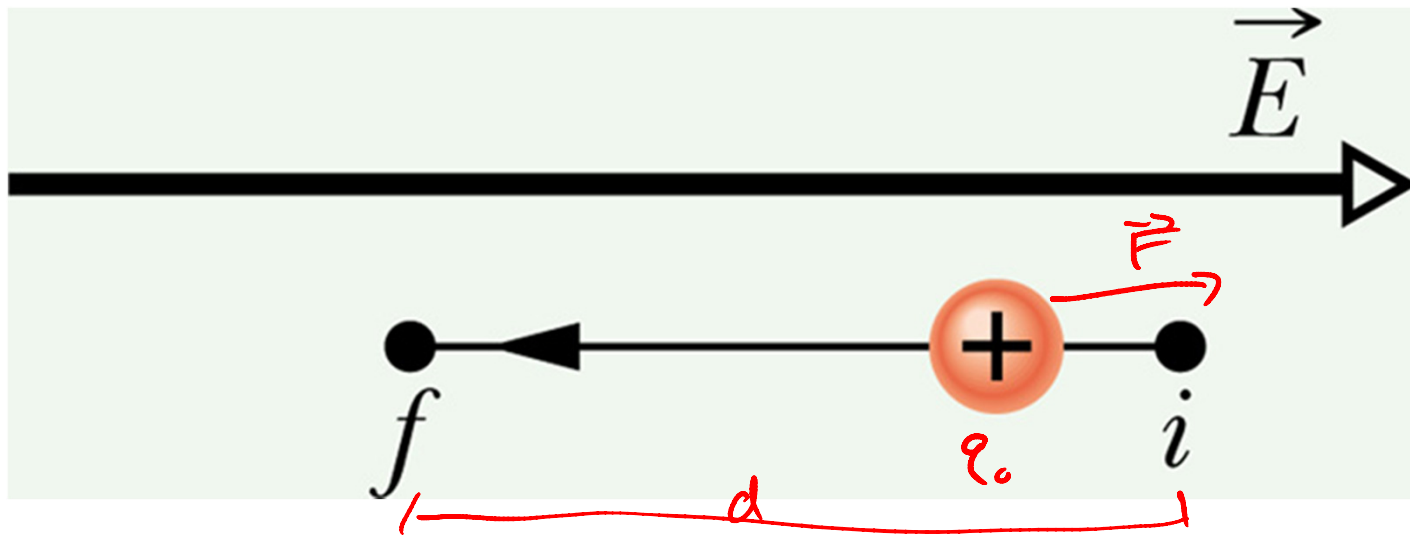
What's the work done to move this charge from i to f ?

$$W = \vec{F} \cdot \vec{d}$$

$$\vec{F} = q_0 \vec{E}$$

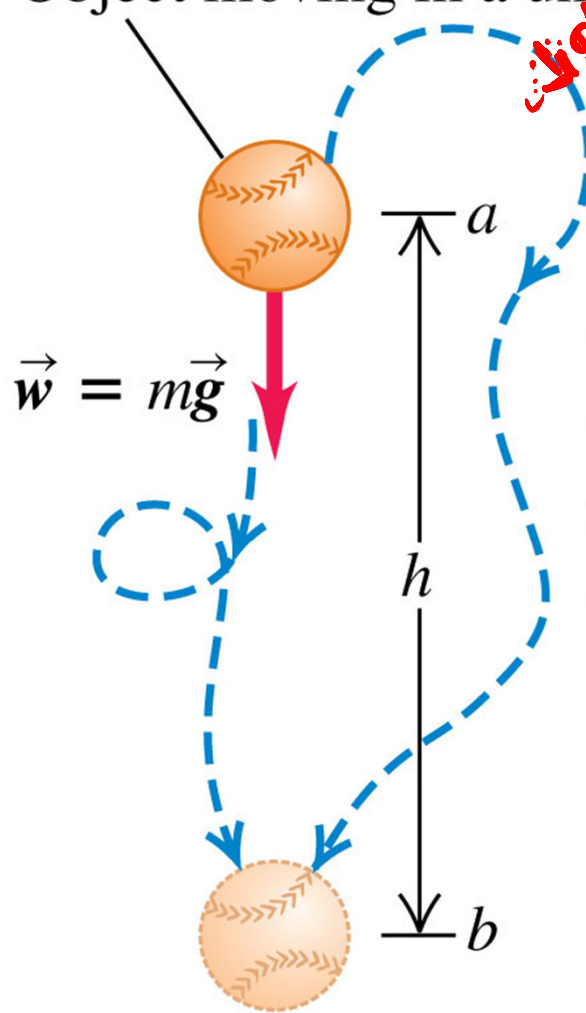
$$W = -q_0 |E| d$$

$$\Delta U = -W = U_f - U_i$$



$$\Delta U = q_0 E d$$

Object moving in a uniform gravitational field

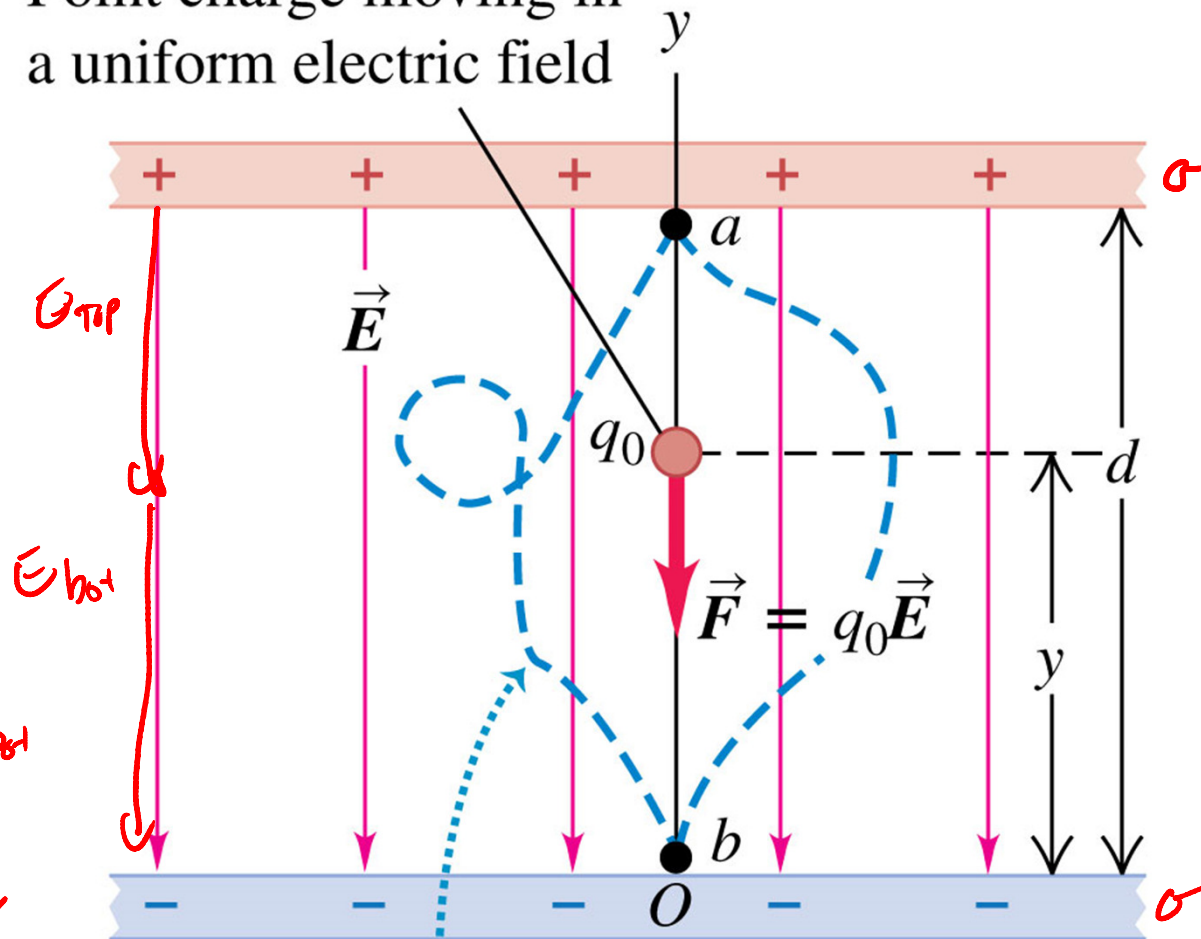


The work done by the gravitational force is the same for any path from a to b :

$$W_{a \rightarrow b} = -\Delta U = \underbrace{mg}_{F}h$$

$$\int dw = \int \vec{F} \cdot d\vec{\ell}$$
$$w = \int_a^b \vec{F} \cdot d\vec{\ell} = |F| \int dl$$
$$w = F \cdot h$$

Point charge moving in a uniform electric field



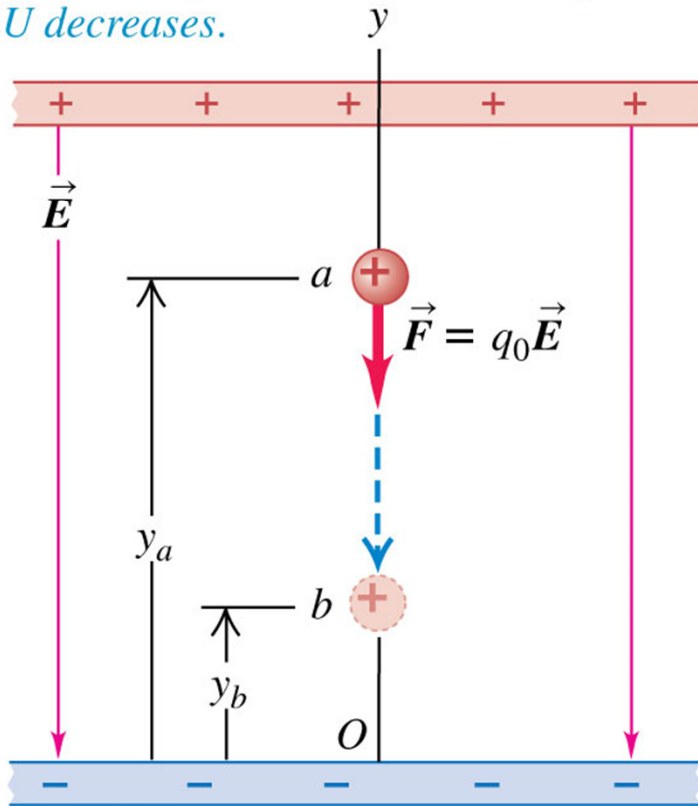
$$\begin{aligned}
 E_{TOT} &= E_{TOP} + E_{bot} \\
 &= \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0} \\
 &= \frac{\sigma}{\epsilon_0}
 \end{aligned}$$

The work done by the electric force is the same for any path from a to b :

$$W_{a \rightarrow b} = -\Delta U = q_0 E d$$

(a) Positive charge moves in the direction of \vec{E} :

- Field does *positive* work on charge.
- U decreases.



© 2012 Pearson Education, Inc.

(b) Positive charge moves opposite \vec{E} :

- Field does *negative* work on charge.
- U increases.

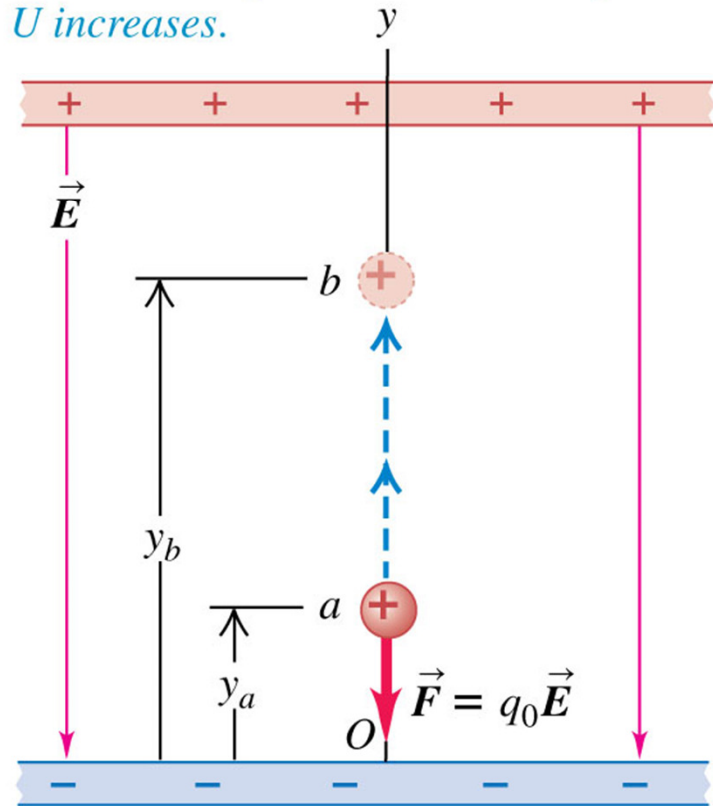
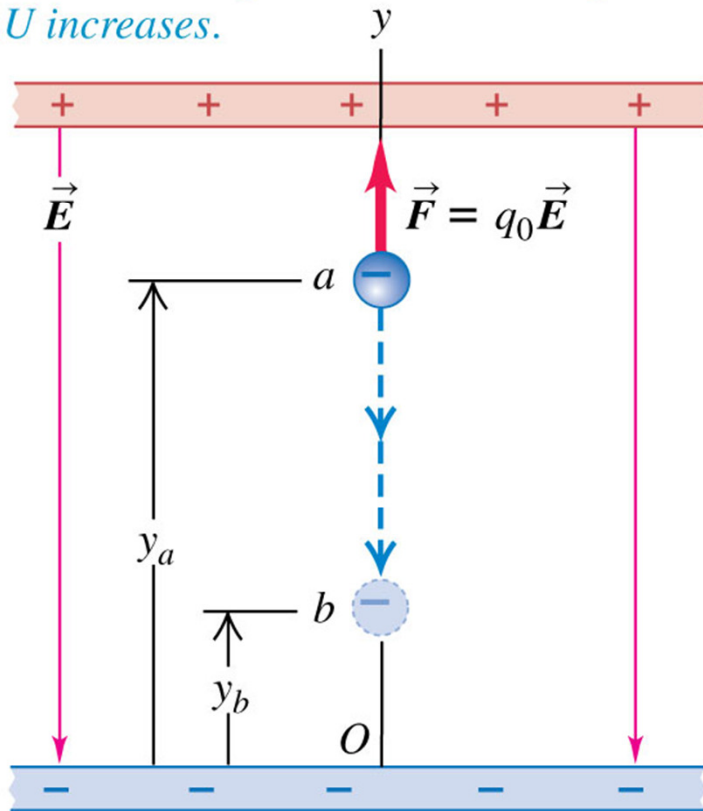


Fig.23.4

(a) Negative charge moves in the direction of \vec{E} :

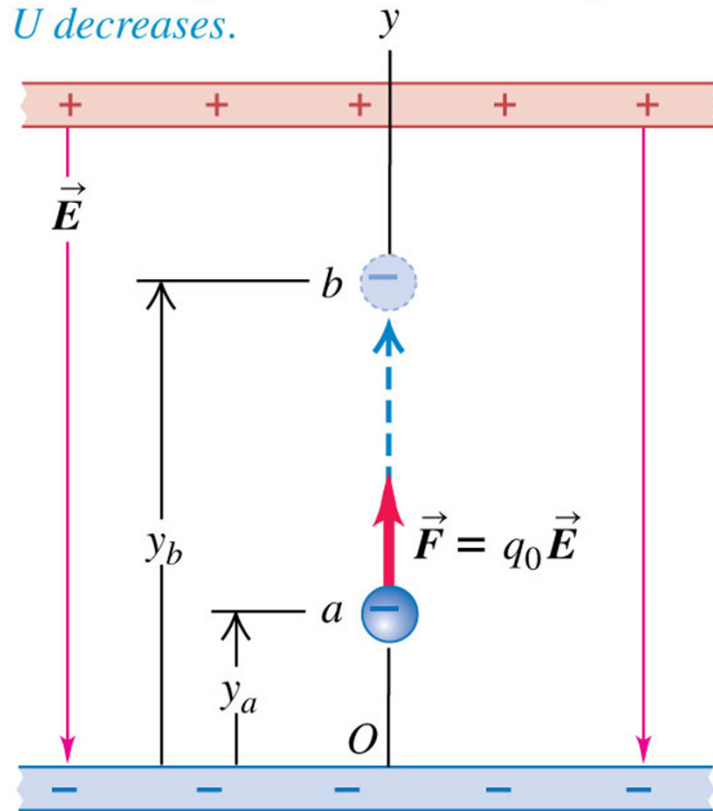
- Field does *negative* work on charge.
- U increases.



© 2012 Pearson Education, Inc.

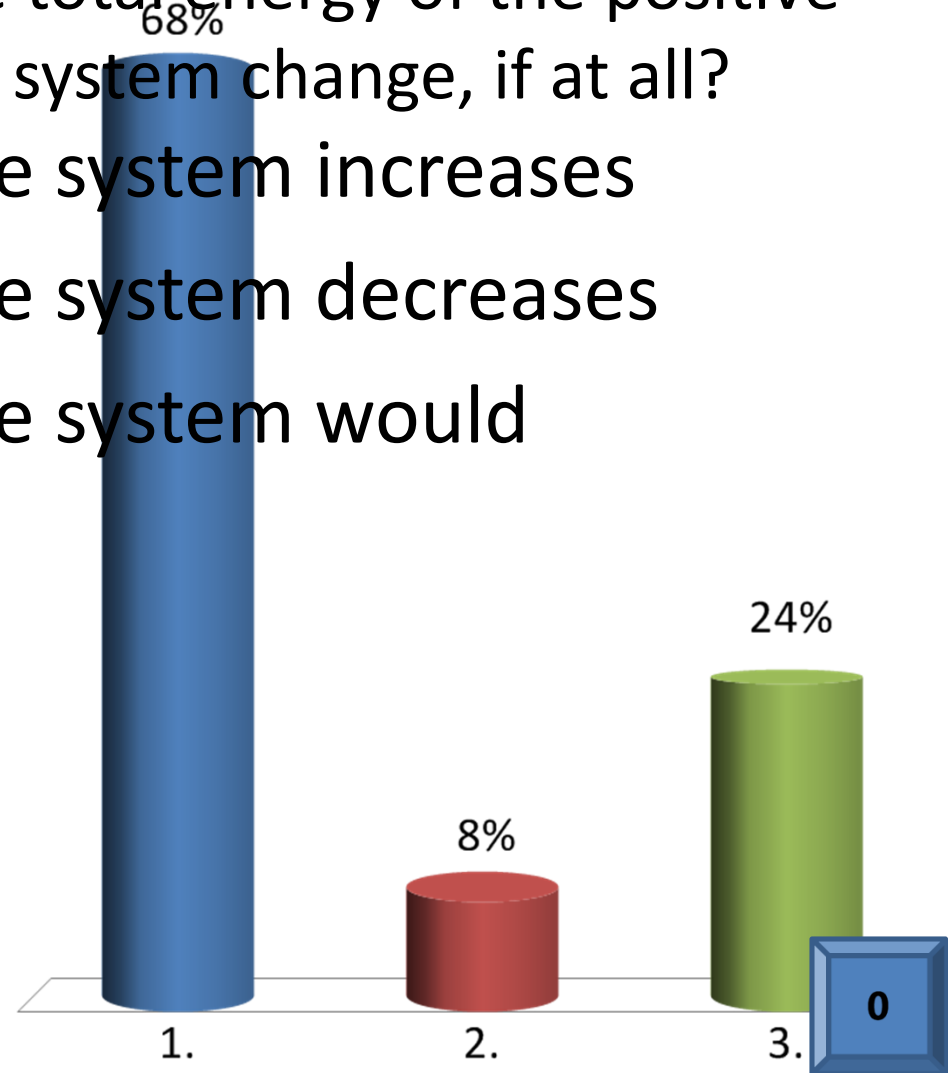
(b) Negative charge moves opposite \vec{E} :

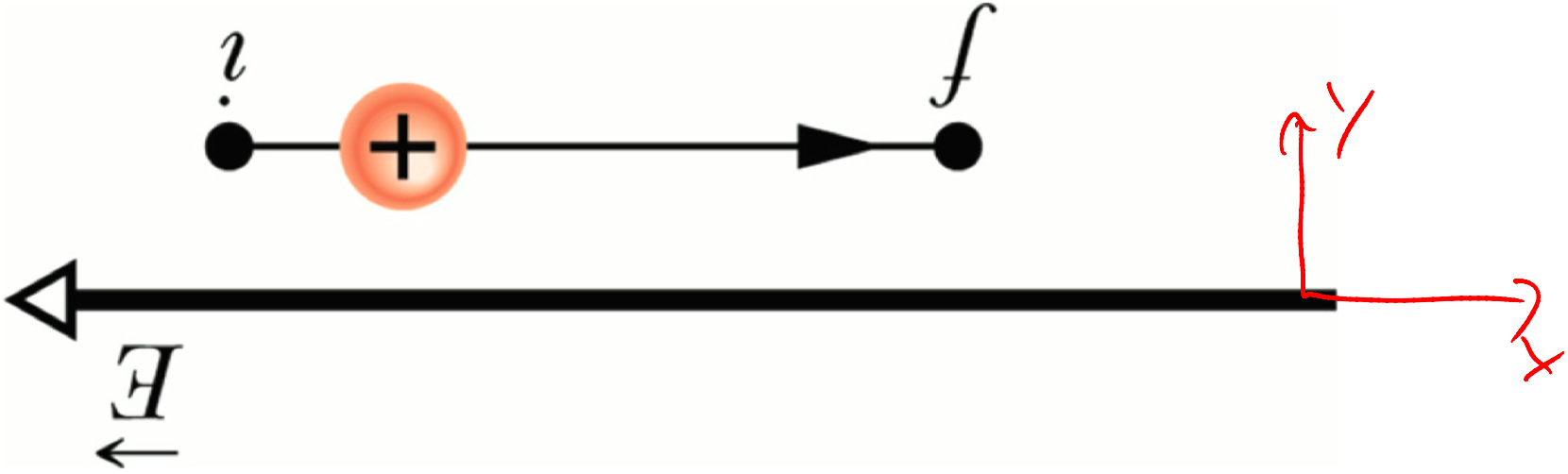
- Field does *positive* work on charge.
- U decreases.

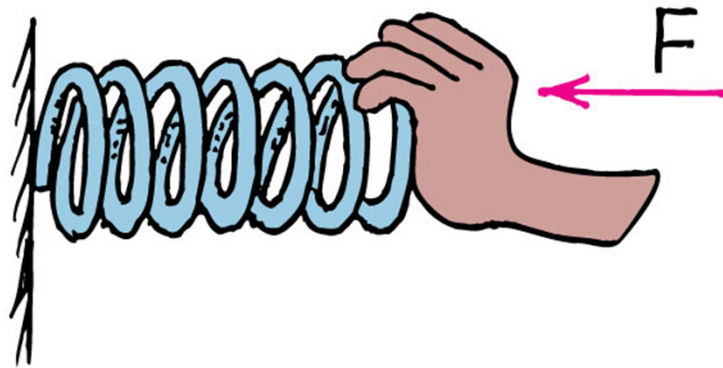
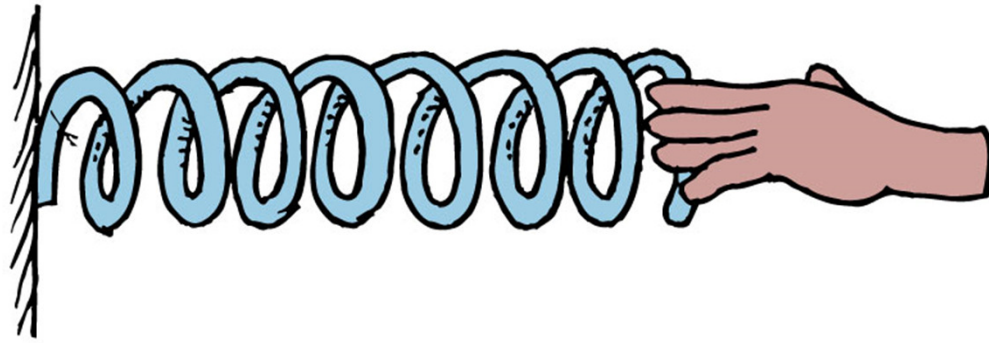


A uniform electric field is directed in the $-x$ direction. If you were to move a positive charge in the $+x$ direction, how would the total energy of the positive charge / electric field system change, if at all?

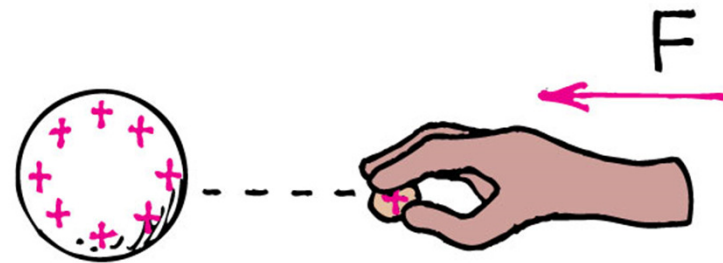
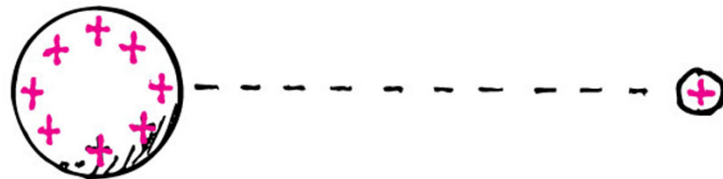
- ✓ 1. The total energy of the system increases
- 2. The total energy of the system decreases
- 3. The total energy of the system would remain unchanged.



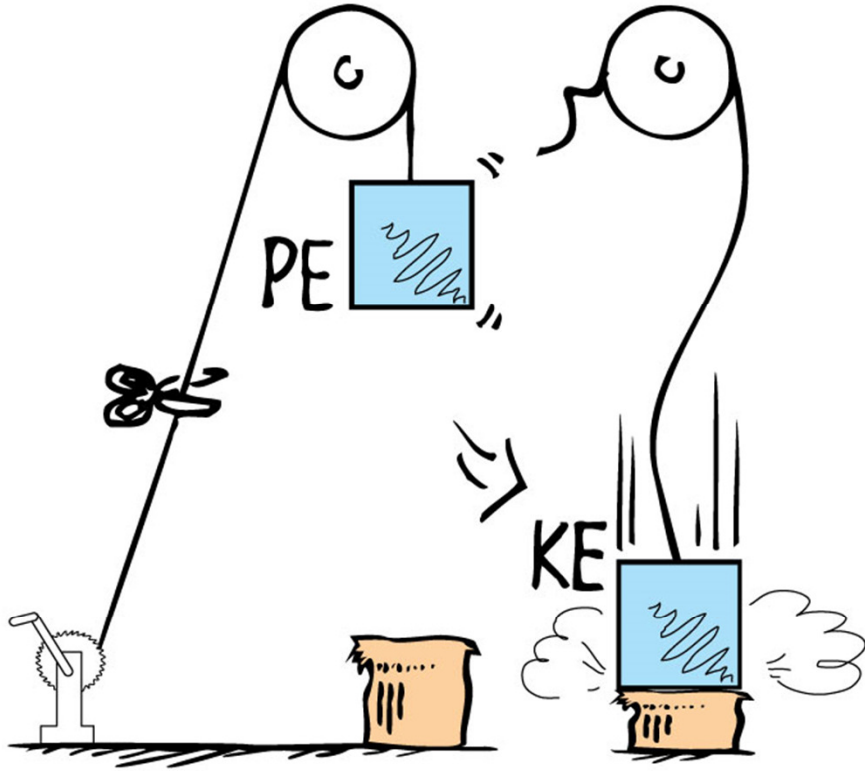




a

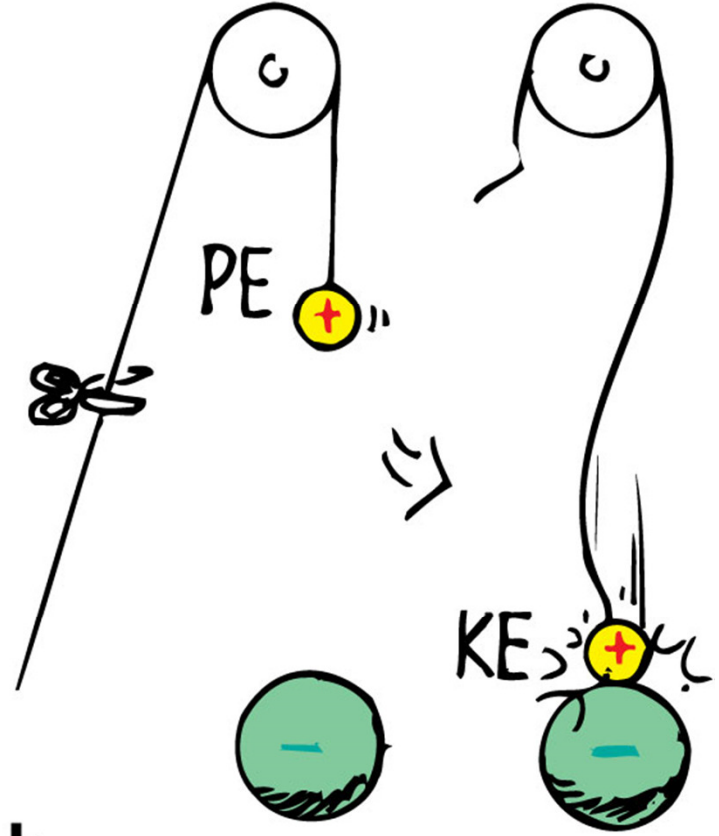


b



a

© 2009 Pearson Education, Inc.



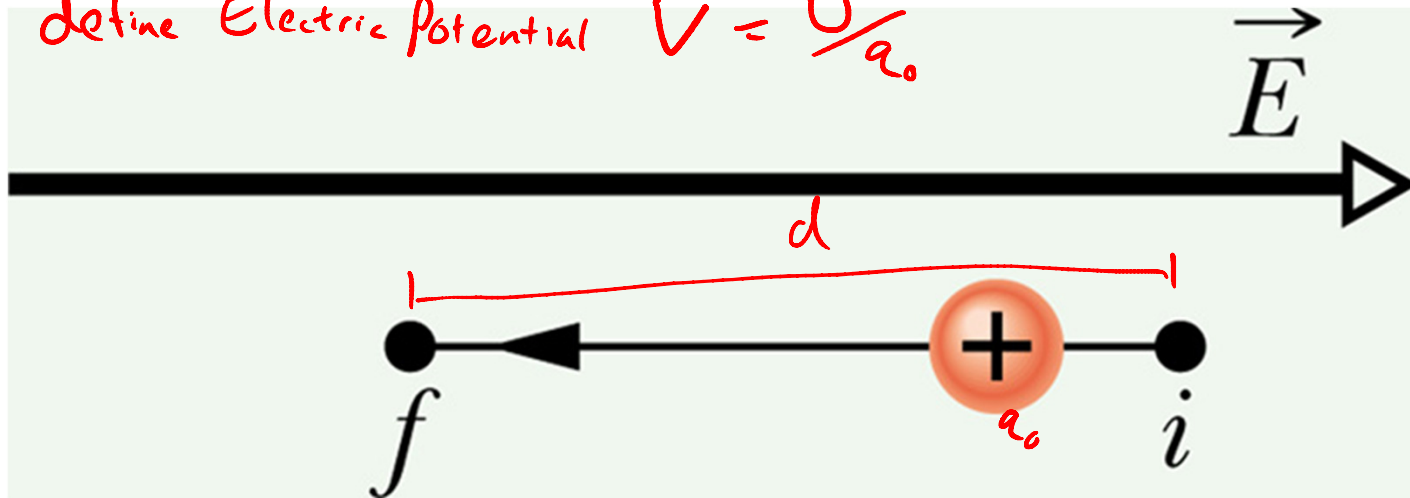
b

How about this "V" thing?

$$\Delta U = -W = -(-qEd) = qEd$$

U = electric potential energy (Joules)

define Electric Potential $V = \frac{U}{q_0}$



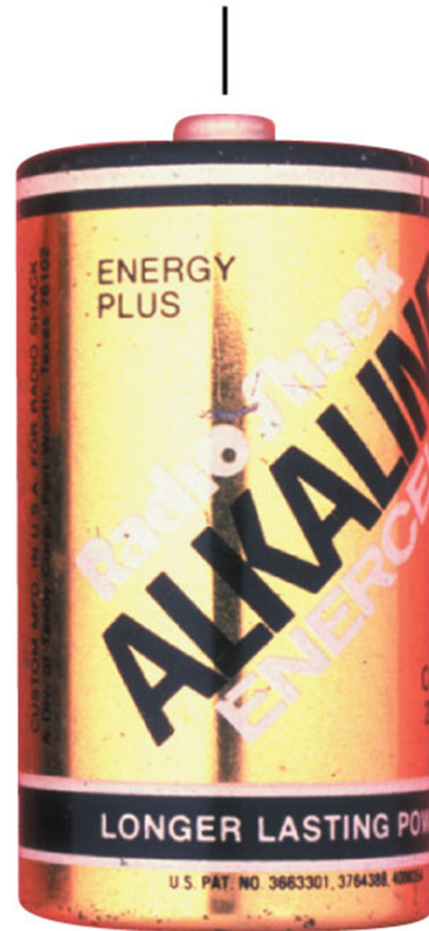
$$\Delta V = V_f - V_i = \frac{U_f}{q_0} - \frac{U_i}{q_0} = \frac{\Delta U}{q_0} = -\frac{W}{q_0}$$

V is in Volts $\frac{J}{C}$

$$1 \frac{W}{C} \cdot \left(\frac{1V \cdot C}{1J}\right) \left(\frac{1J}{1N \cdot m}\right) = 1 \frac{V}{m}$$

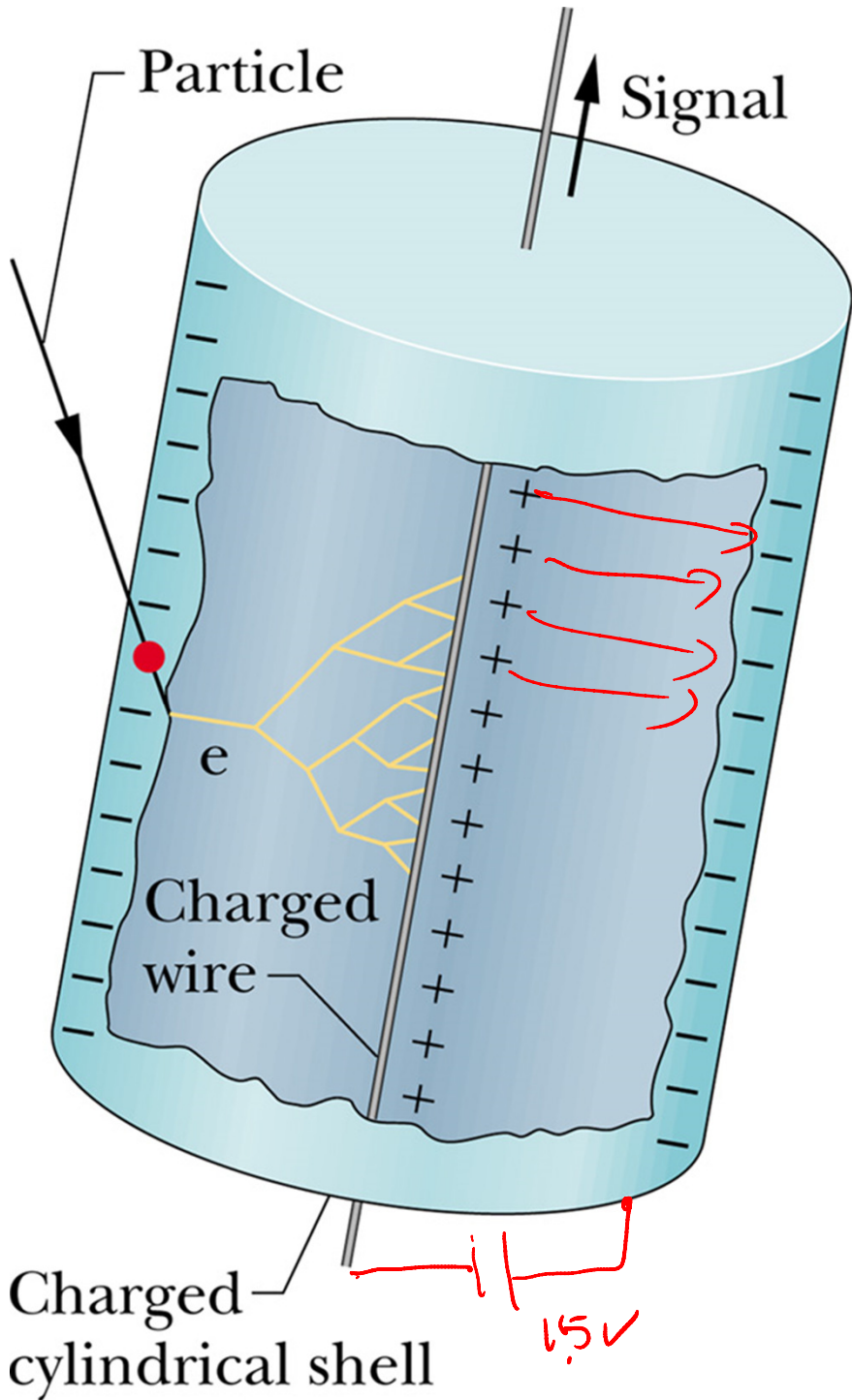
$$E = \frac{N}{C}$$

Point *a* (positive terminal)



$$V_{ab} = 1.5 \text{ volts}$$

Point *b* (negative terminal)



$$V = 1.5V$$

$$U = V \cdot q = (1.5V)(1e) = 1.5eV$$

$$1eV = 1.6 \times 10^{-19} J$$

Look @ X-ray machine

80kV

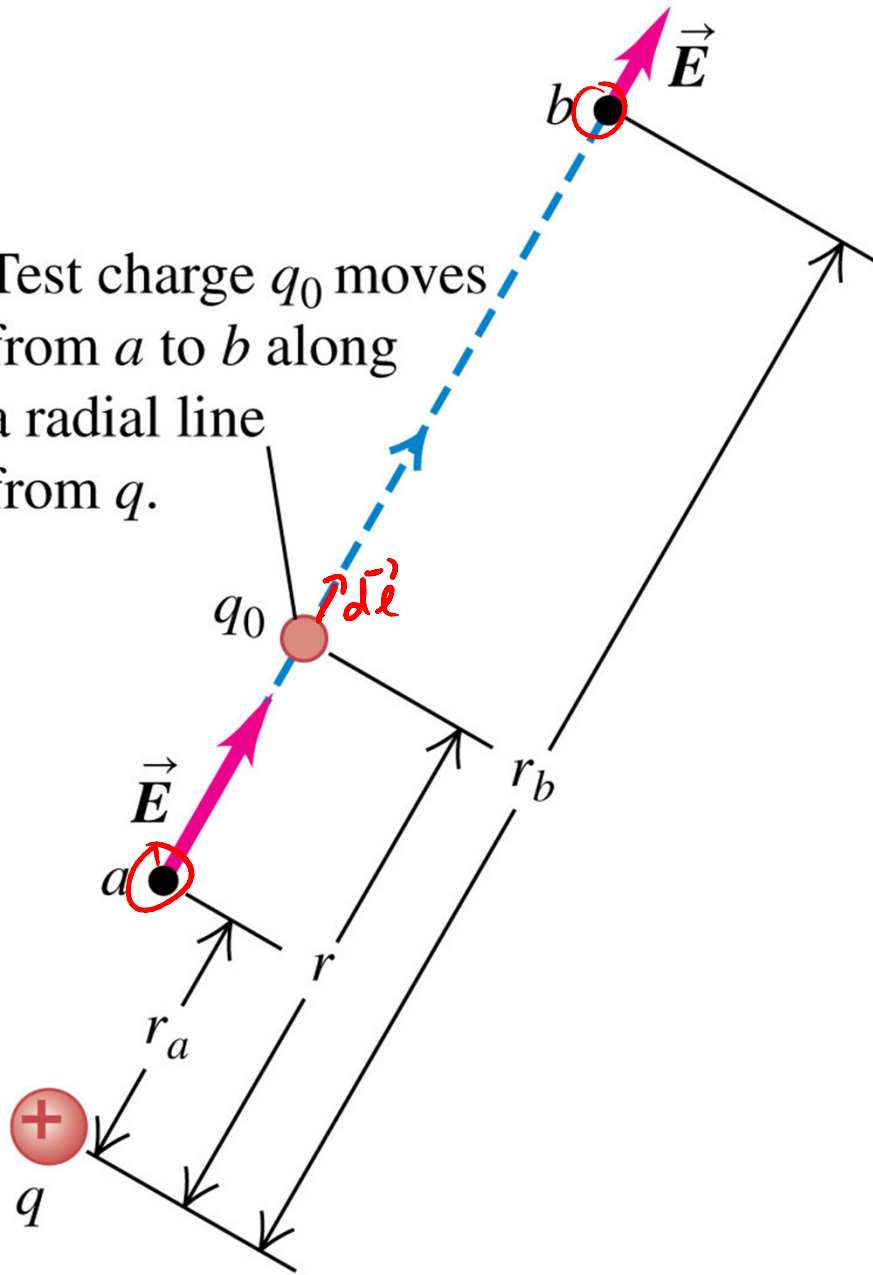
beam of e^- across 80kV = 80keV

Worksheet time:

Work done by an electric field...

What's the work done to move this charge from a to b ?

Test charge q_0 moves from a to b along a radial line from q .



$$\vec{F} = \vec{E} \cdot q_0 = \left(\frac{kq}{r^2} \right) q_0 = \frac{kqq_0}{r^2}$$

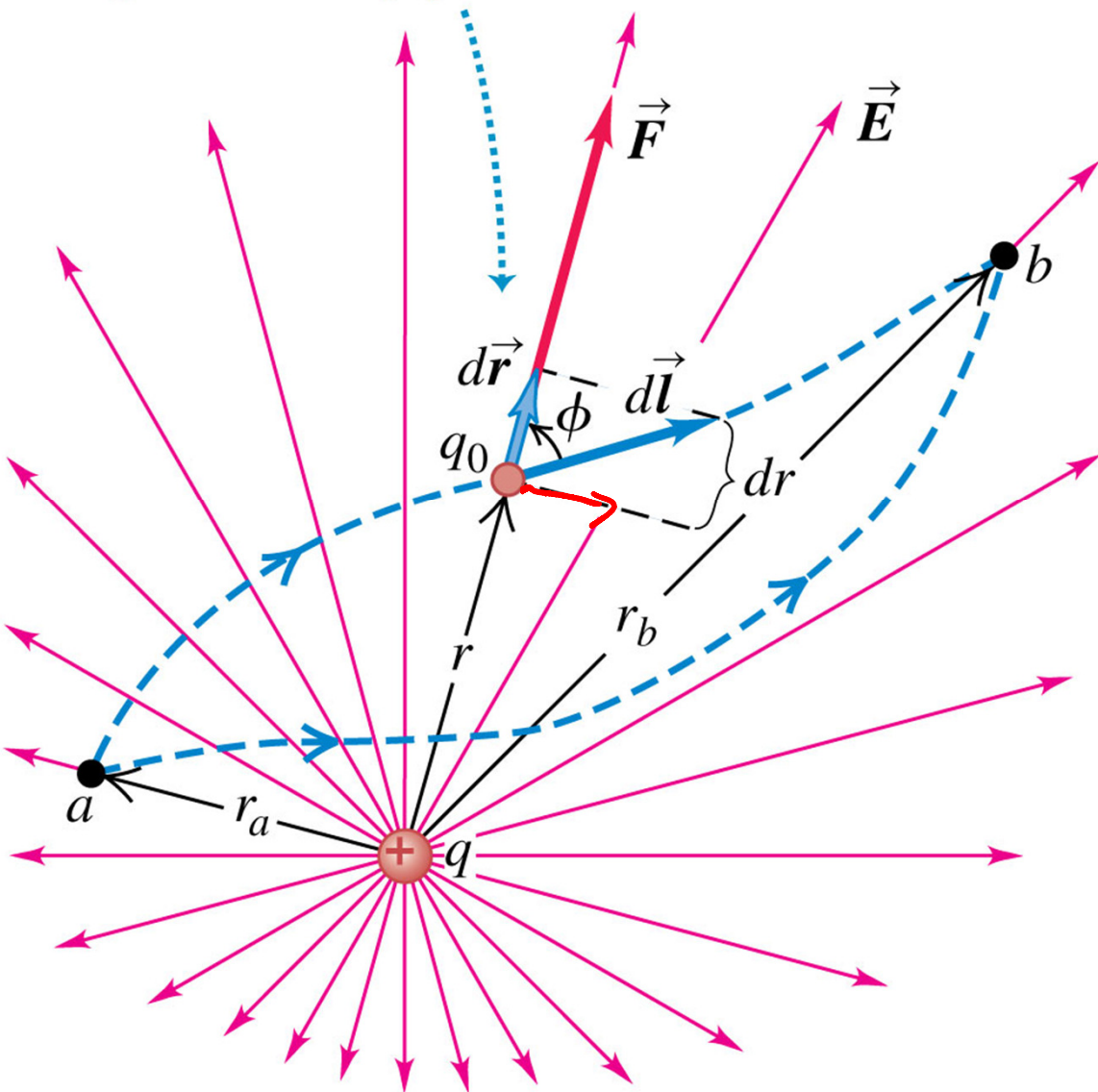
$$W_{a \rightarrow b} = \int_a^b \vec{F} \cdot d\vec{r} \quad d\vec{r} = dr \hat{r}$$

$$W_{a \rightarrow b} = \int_a^b |\vec{F}| dr \cos 0^\circ$$

$$W_{a \rightarrow b} = \int_a^b \frac{kqq_0}{r^2} dr \quad \left(\int \frac{d}{r^2} = -\frac{1}{r} \right)$$

$$= kqq_0 \left(\frac{1}{r_a} - \frac{1}{r_b} \right)$$

Test charge q_0 moves from a to b along an arbitrary path.



$$dW = \vec{F} \cdot d\vec{l}$$

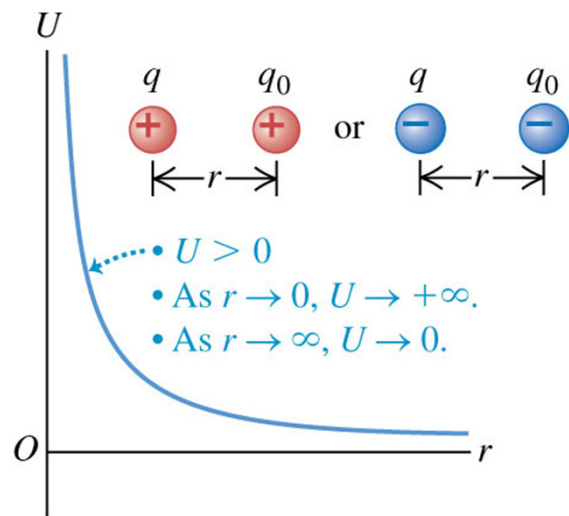
$$= |\vec{F}| dl \cos\theta$$

$$dl \cos\theta = dr$$

Only radial ~~path~~ matters

$$-W = \Delta U$$

(a) q and q_0 have the same sign.

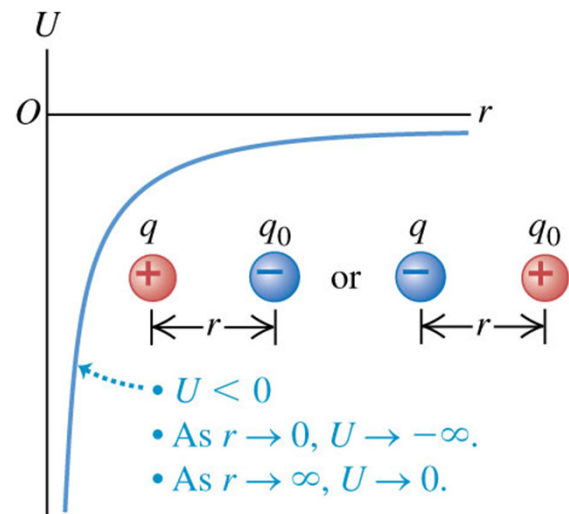


U is always a relative thing:
Energy Here vs. Energy there.

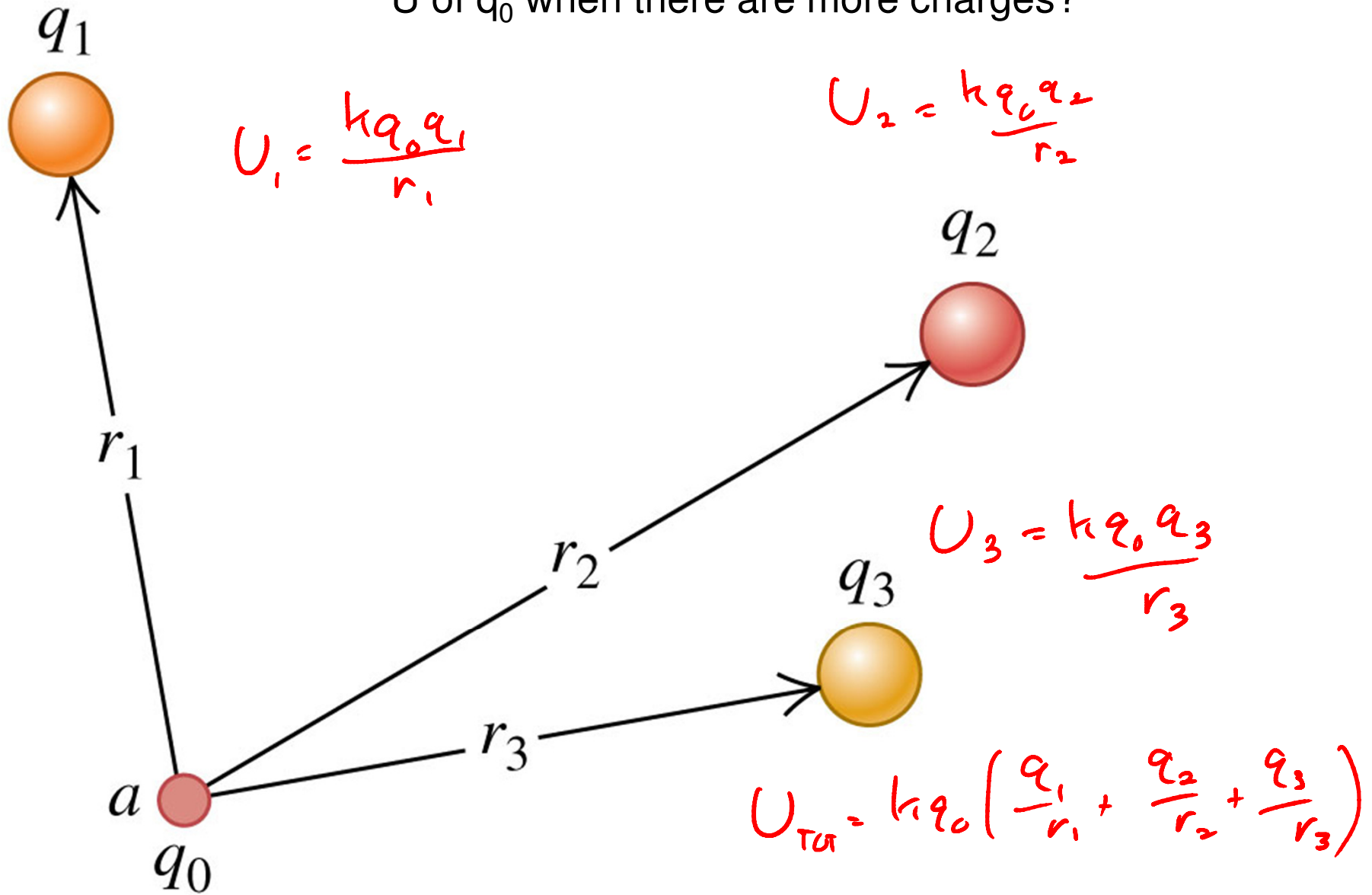
We can pick a "zero"...

$$W = k q q_0 \left(\frac{1}{r_a} - \frac{1}{r_b} \right) = -\Delta U$$
$$\Delta U = k q q_0 \left(\frac{1}{r_b} - \frac{1}{r_a} \right)$$
$$r = \infty, U = 0$$

(b) q and q_0 have opposite signs.

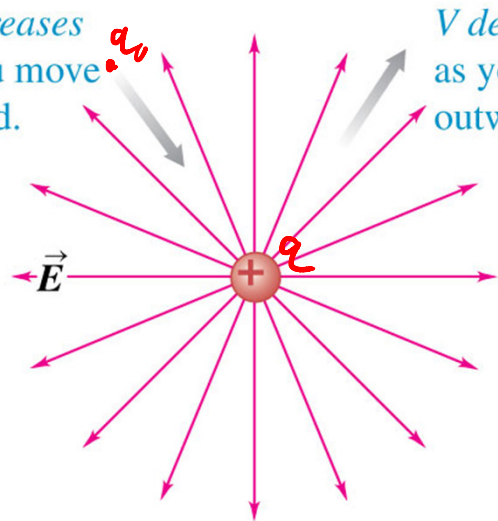


U of q_0 when there are more charges?



(a) A positive point charge

V increases as you move inward.



V decreases as you move outward.

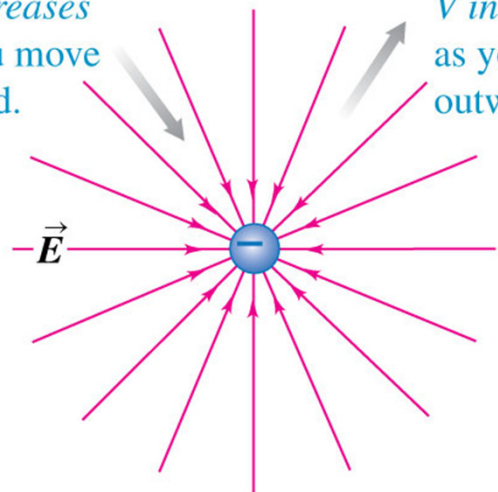
$$V = \frac{U}{q_0} = \frac{k q_0 q}{r q_0}$$

$$V = \frac{k q}{r}$$

$$V(\infty) = 0$$

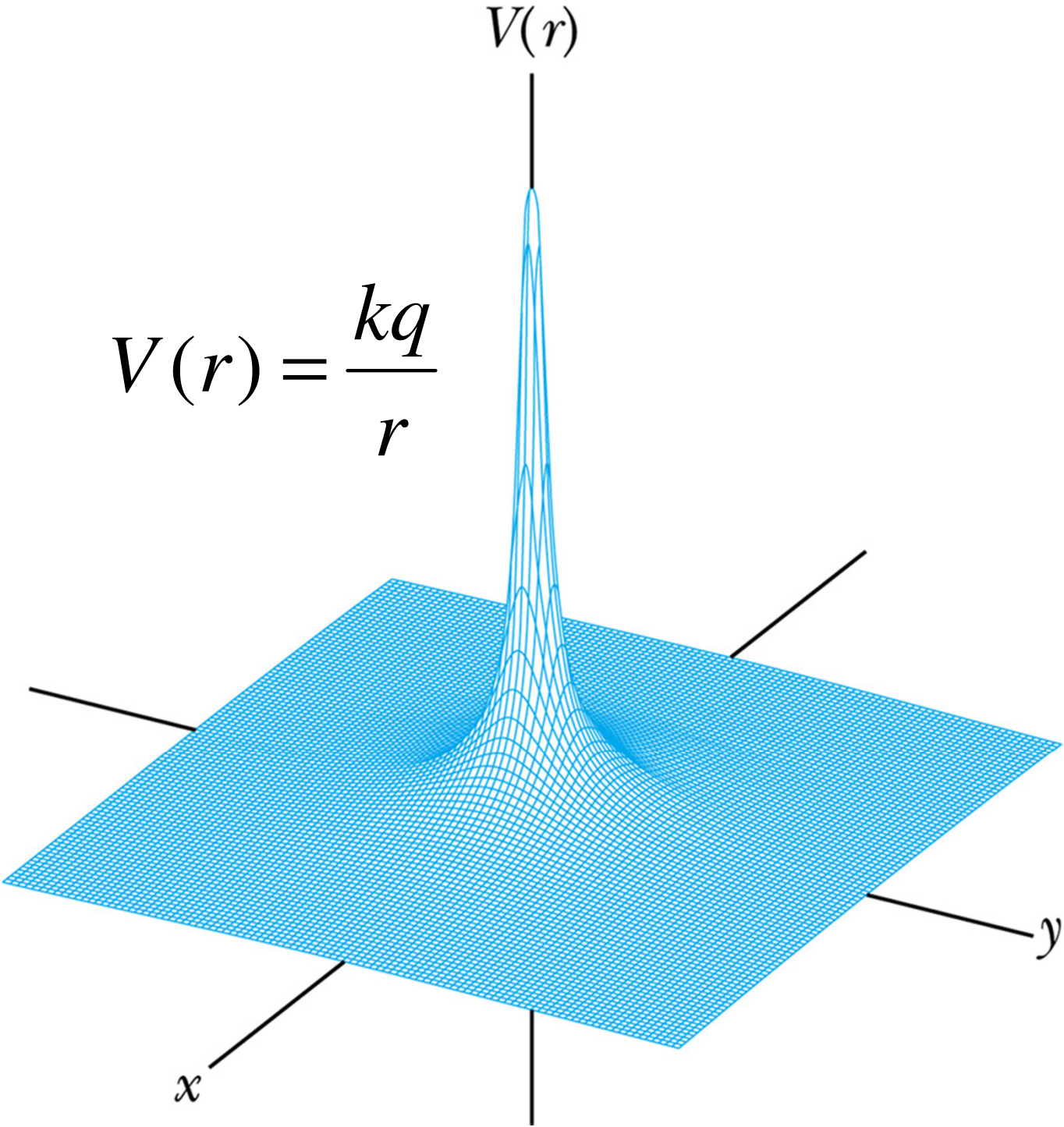
(b) A negative point charge

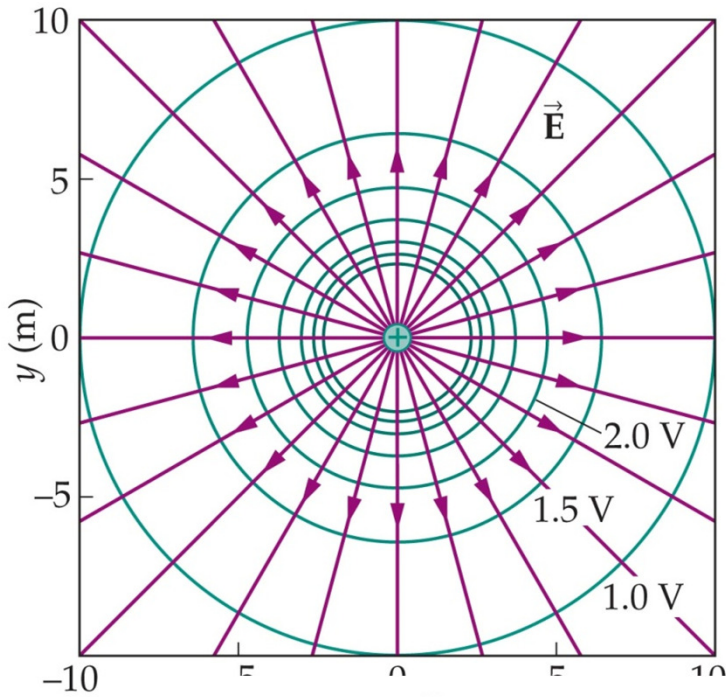
V decreases as you move inward.



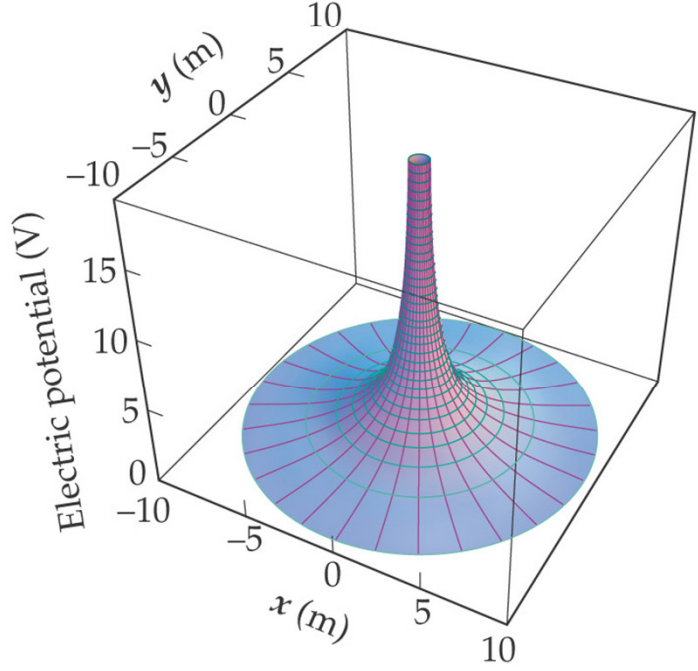
V increases as you move outward.

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

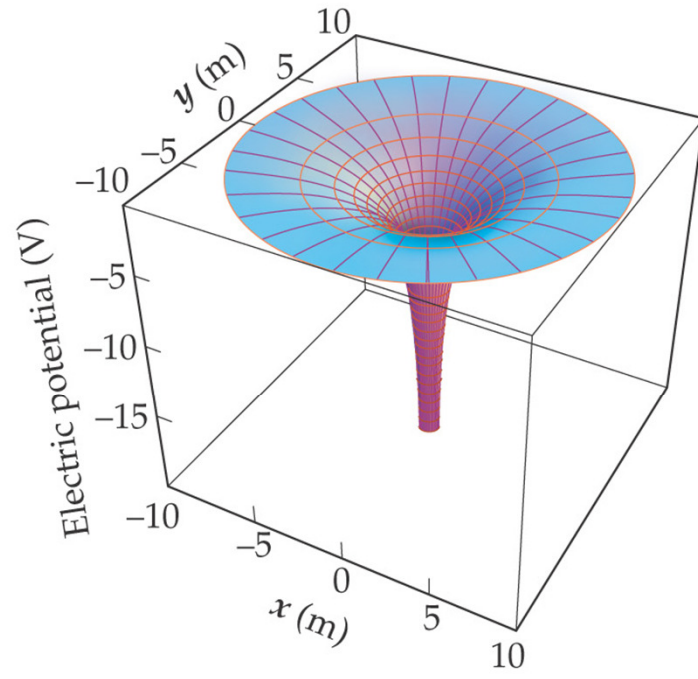




© 2010 Pearson Educator



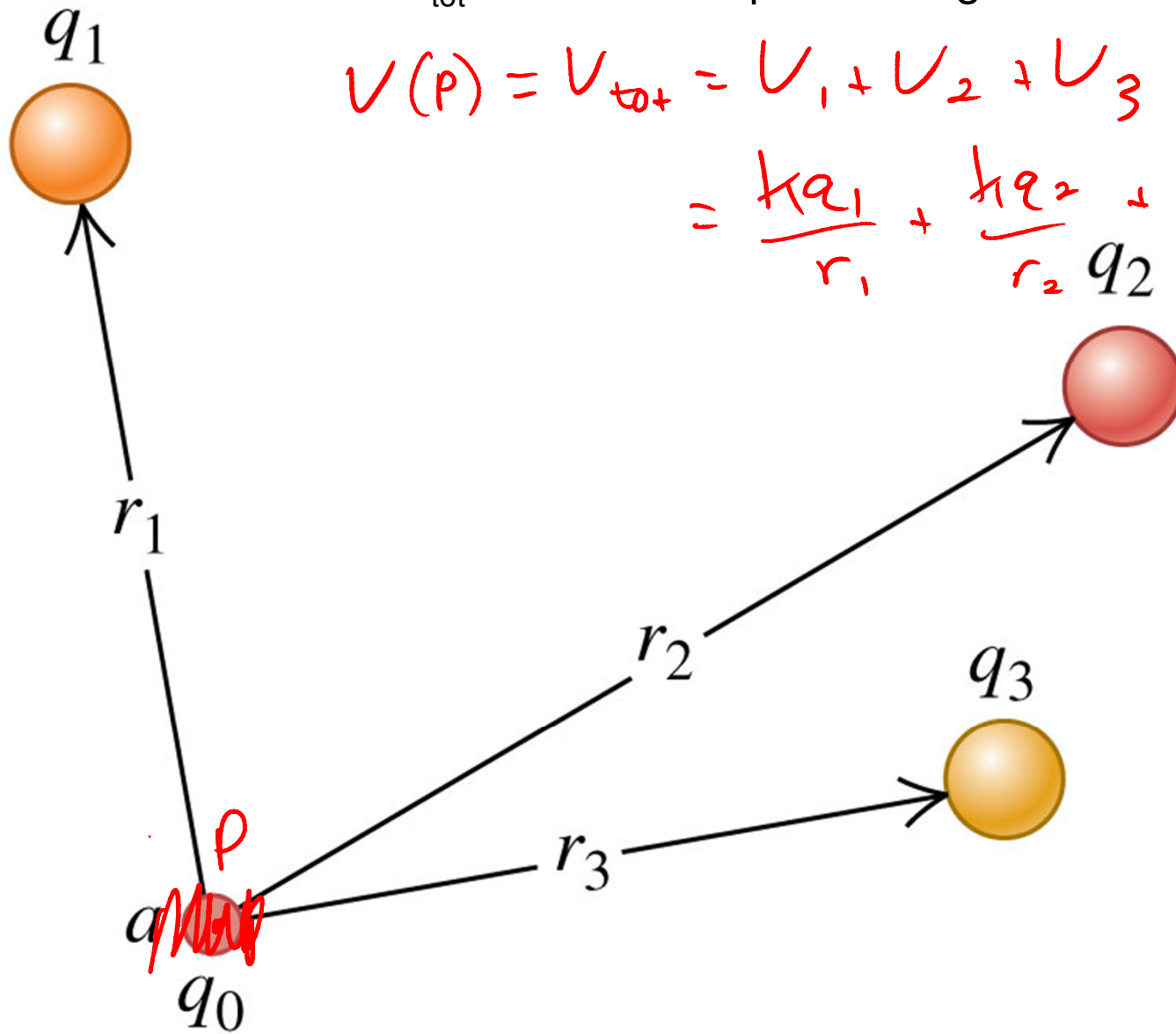
(a)

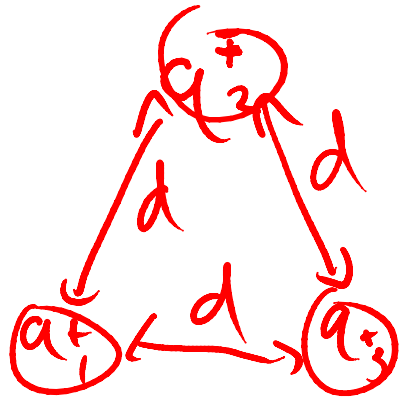


(b)

What's V_{tot} from several point charges?

$$V(P) = V_{\text{tot}} = V_1 + V_2 + V_3 \\ = \frac{kq_1}{r_1} + \frac{kq_2}{r_2} + \frac{kq_3}{r_3}$$





U of this collection?

U of a charge = q of that charge V at that place

$$\text{So: } U_1 = q_1 V_1$$

V_1 is caused by q_2, q_3 : $\frac{kq_2}{d} + \frac{kq_3}{d}$

$$\text{So, } U_1 = q_1 \left(\frac{kq_2}{d} + \frac{kq_3}{d} \right)$$

like wise for U_2, U_3

$$\text{Total } U = U_1 + U_2 + U_3$$