Potential

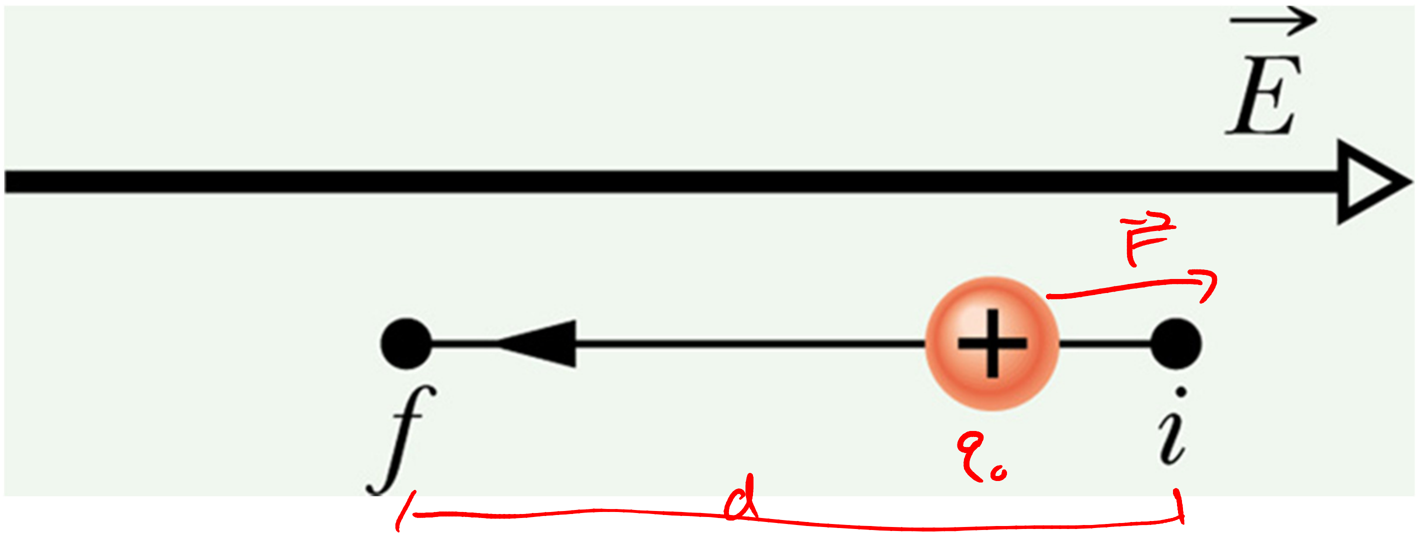
What's the work done to move this charge from *i* to *f* ?

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

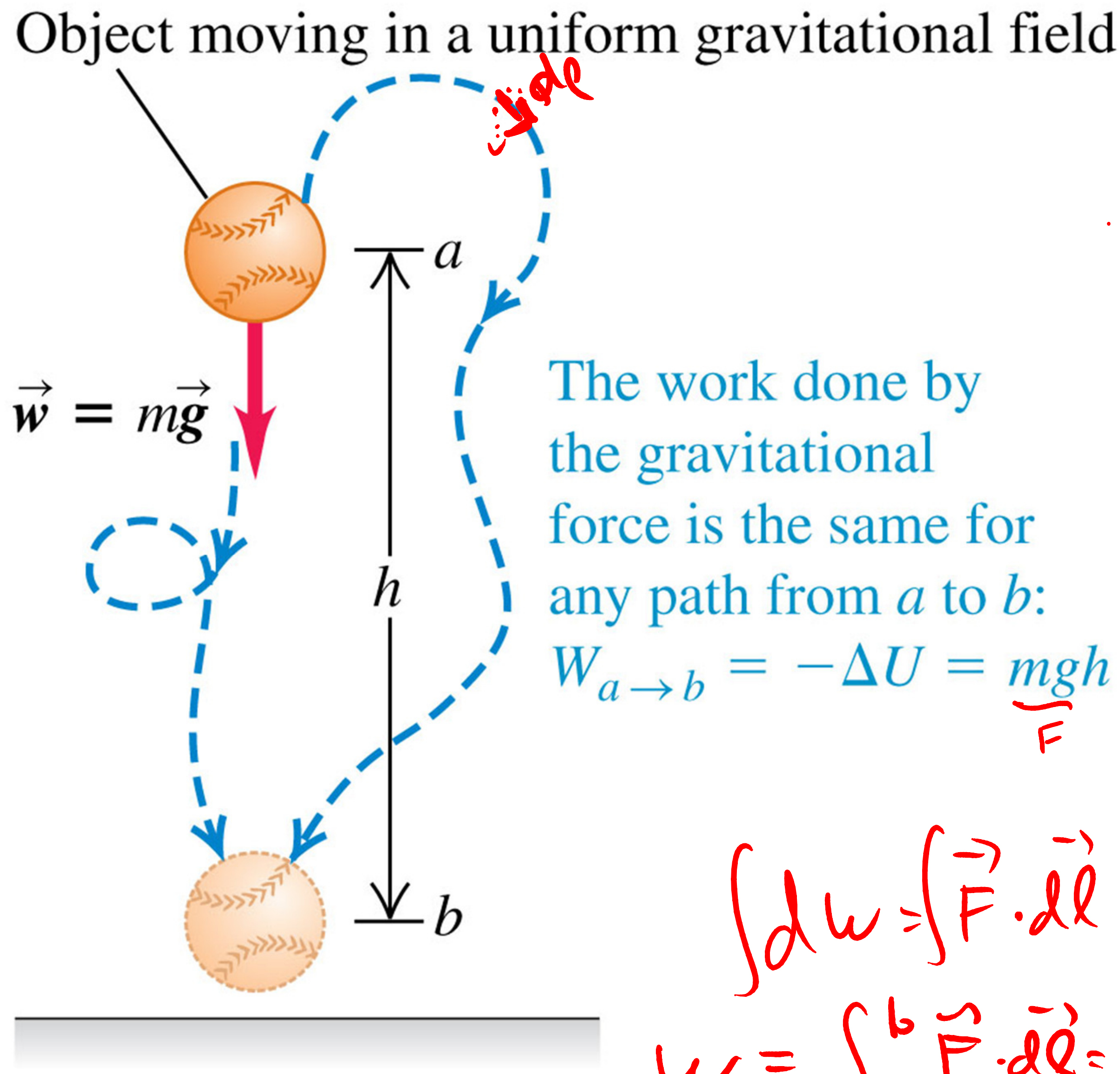
$\vec{F} = q_0 \vec{E}$

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

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



$\Delta U = q_0 E d$



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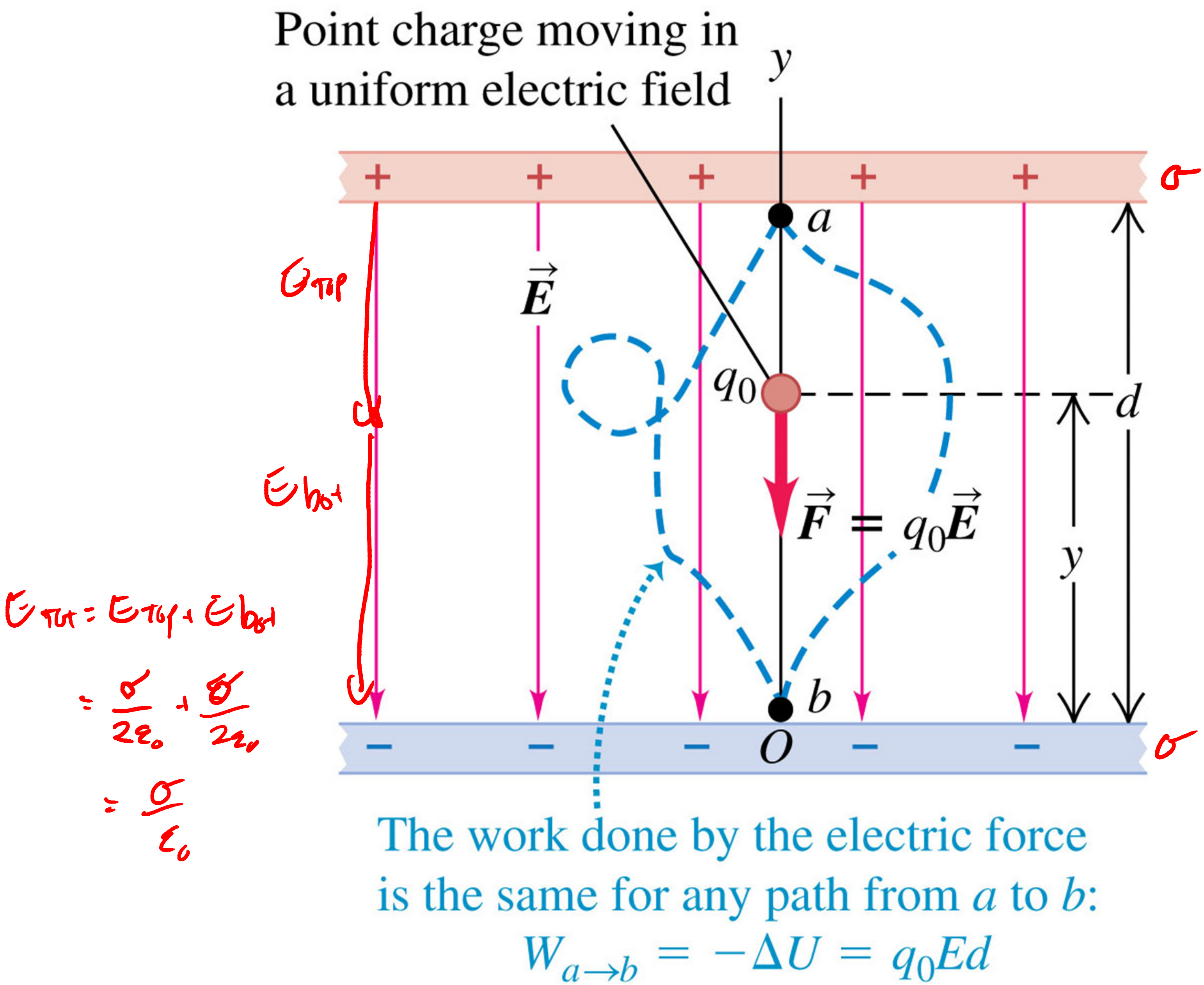
$$\int dw = \int \vec{F} \cdot \vec{d\ell}$$

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

$$w = F \cdot h$$



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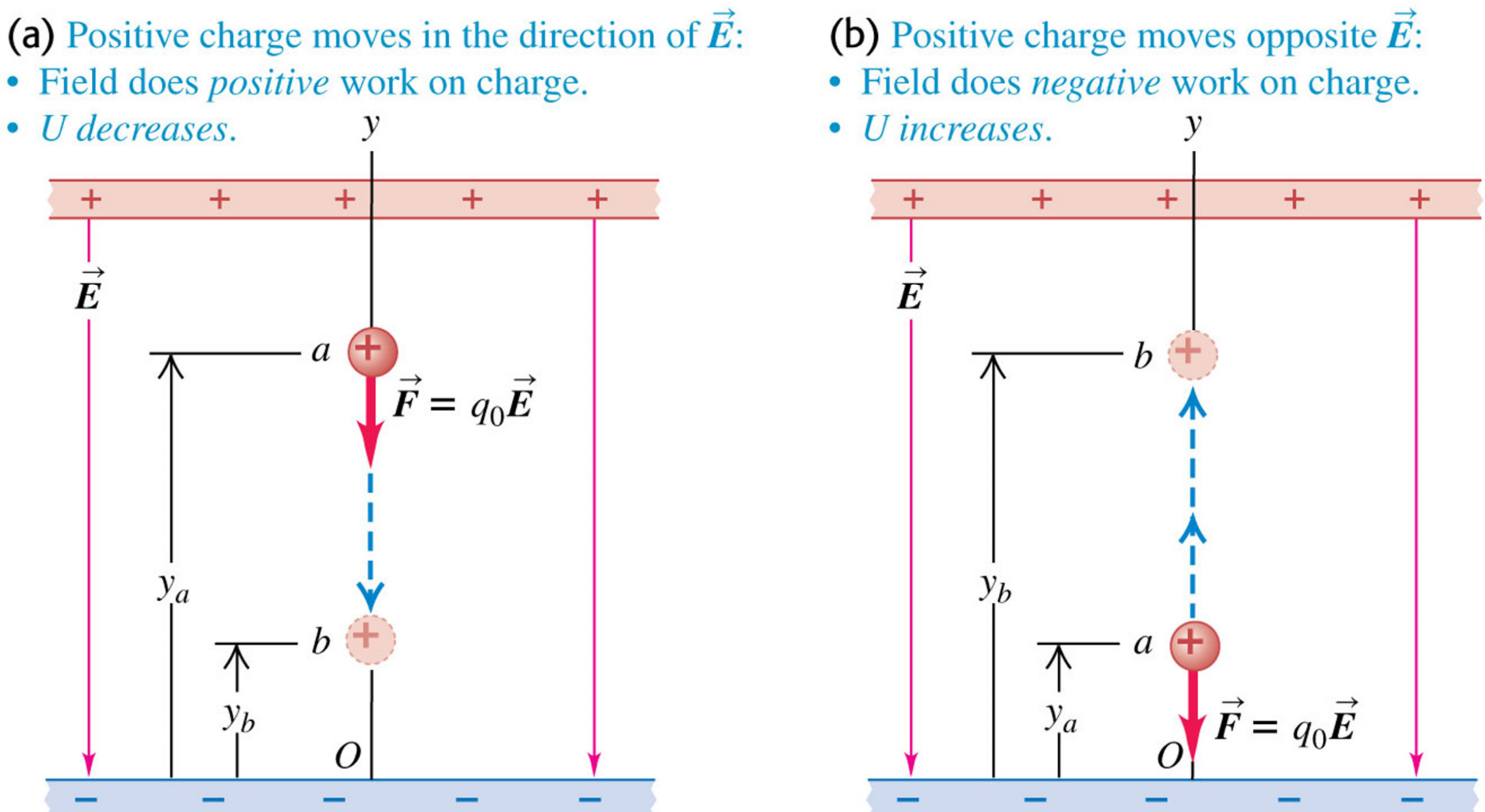

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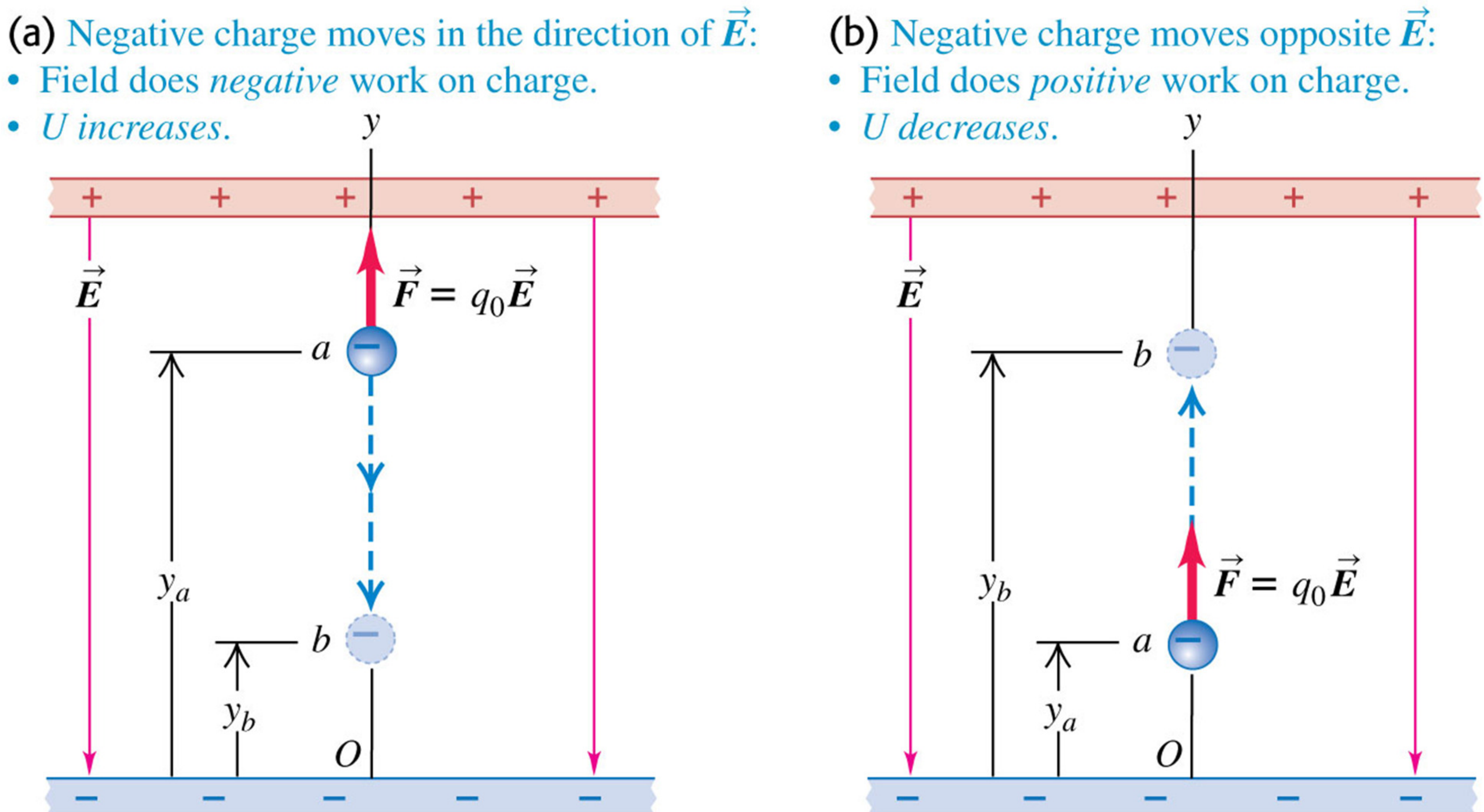
Fig.23.4



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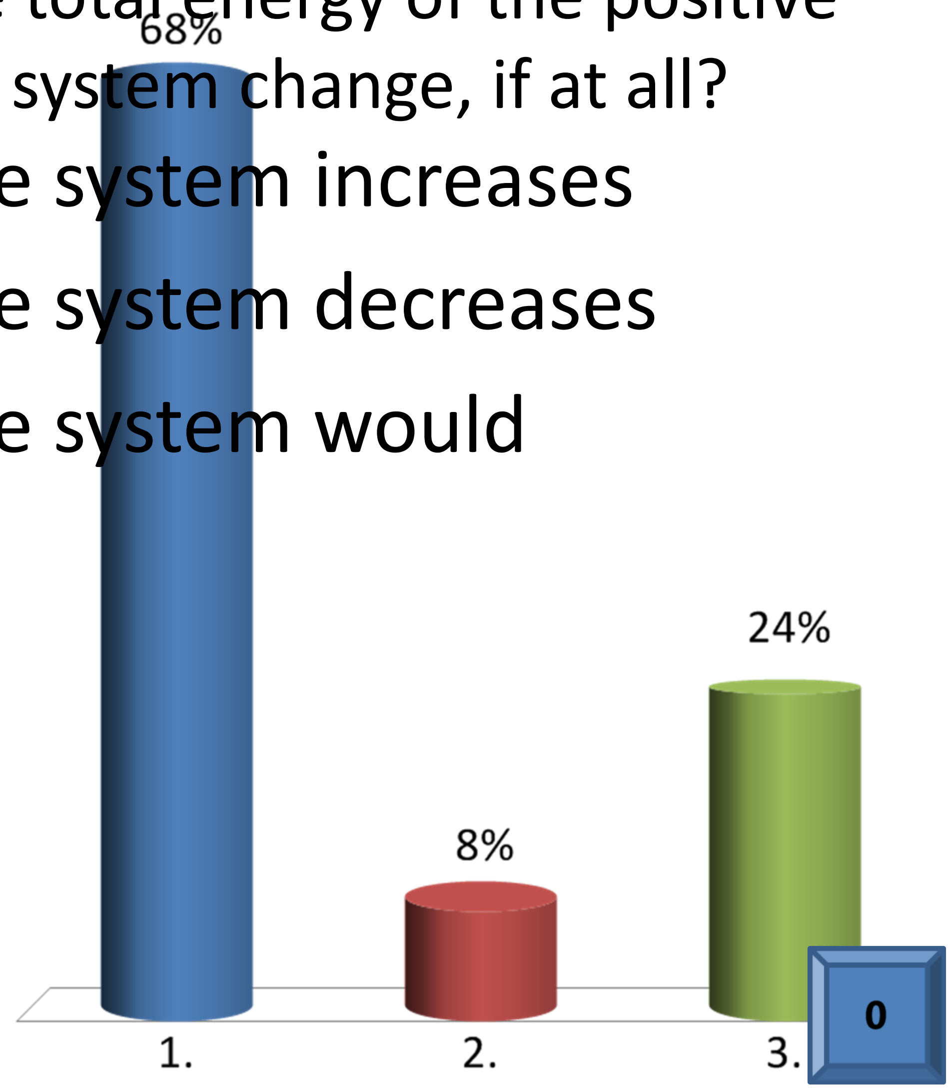
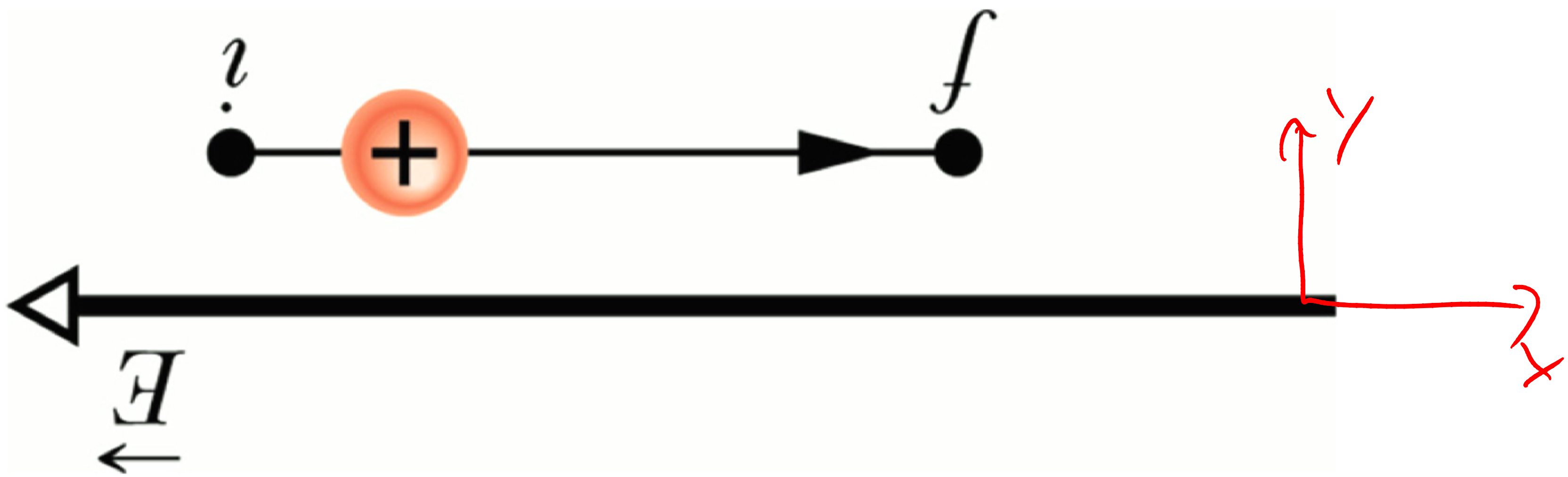
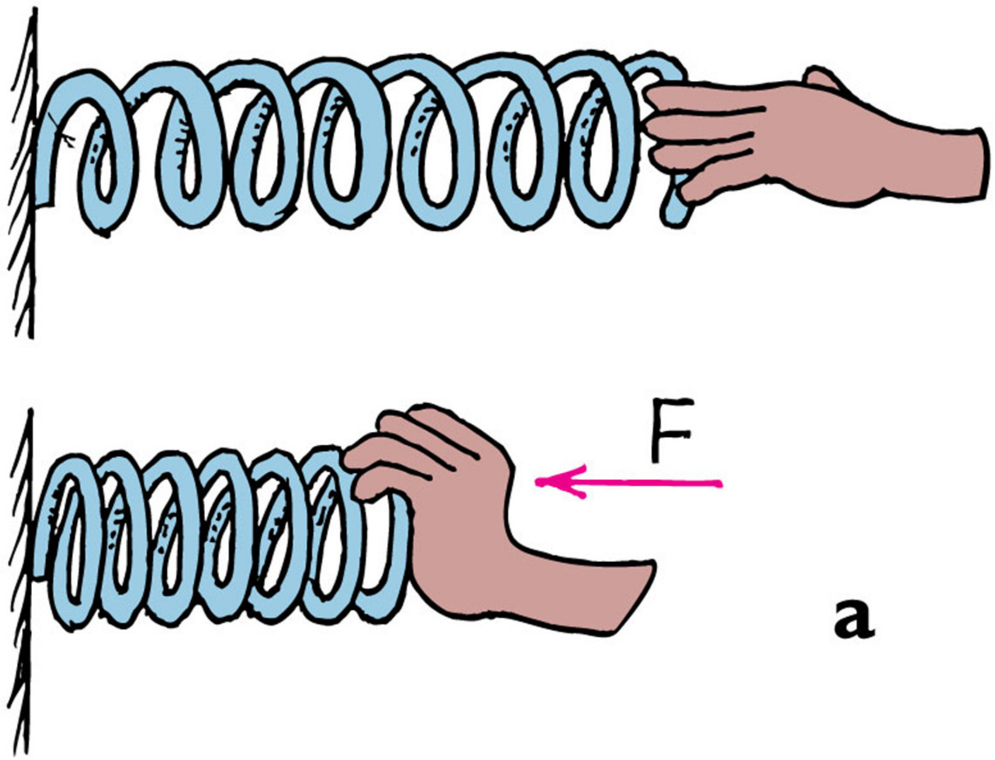
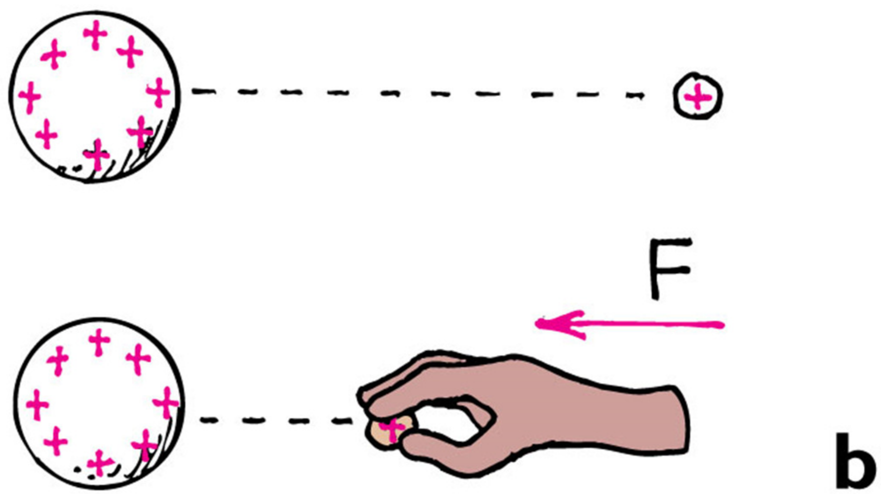
A uniform electric field is directed in the -*x* direction. If you were to move a positive charge in the +*x* direction, how would the total energy of the positive charge / electric field system change, if at all?

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.




i
f
E
y
x





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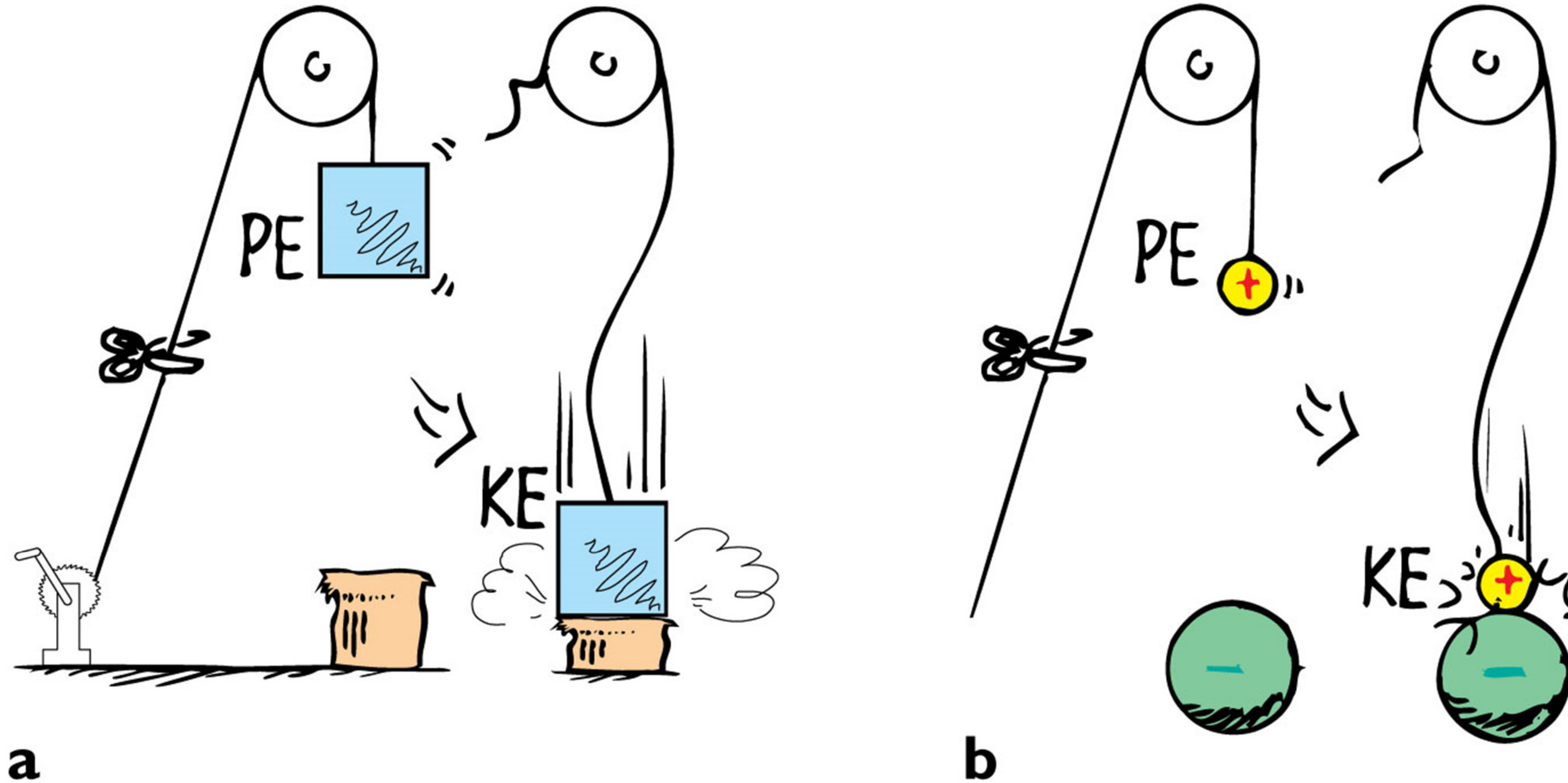

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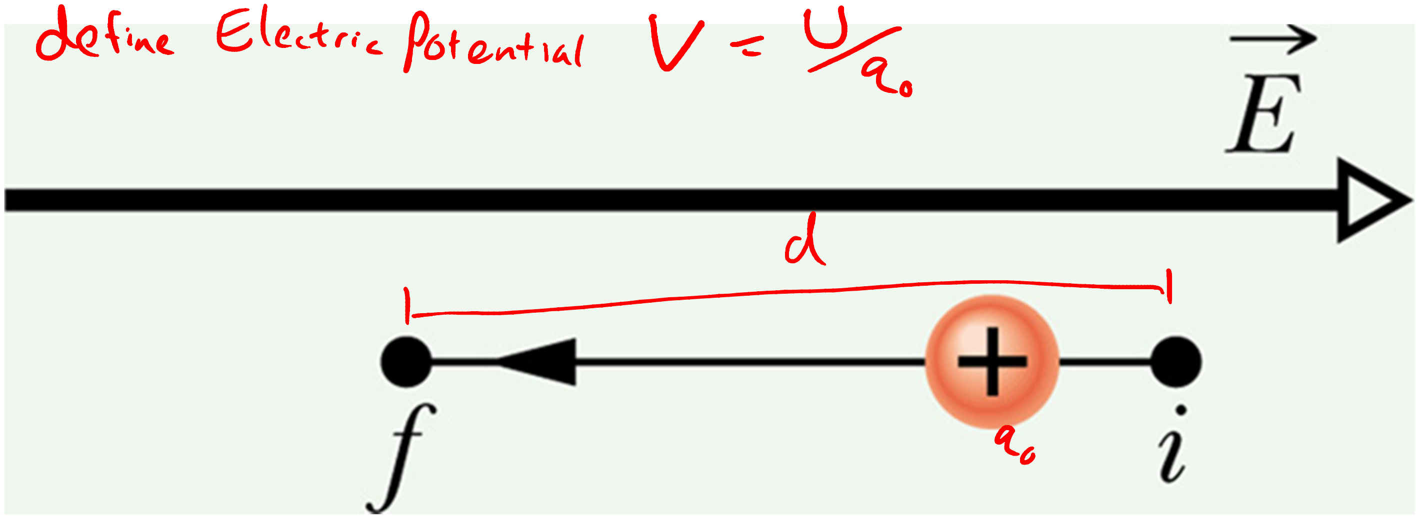
How about this “V” thing?

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

U = electric potential energy (Joules)

define Electric Potential $V = U/q_0$

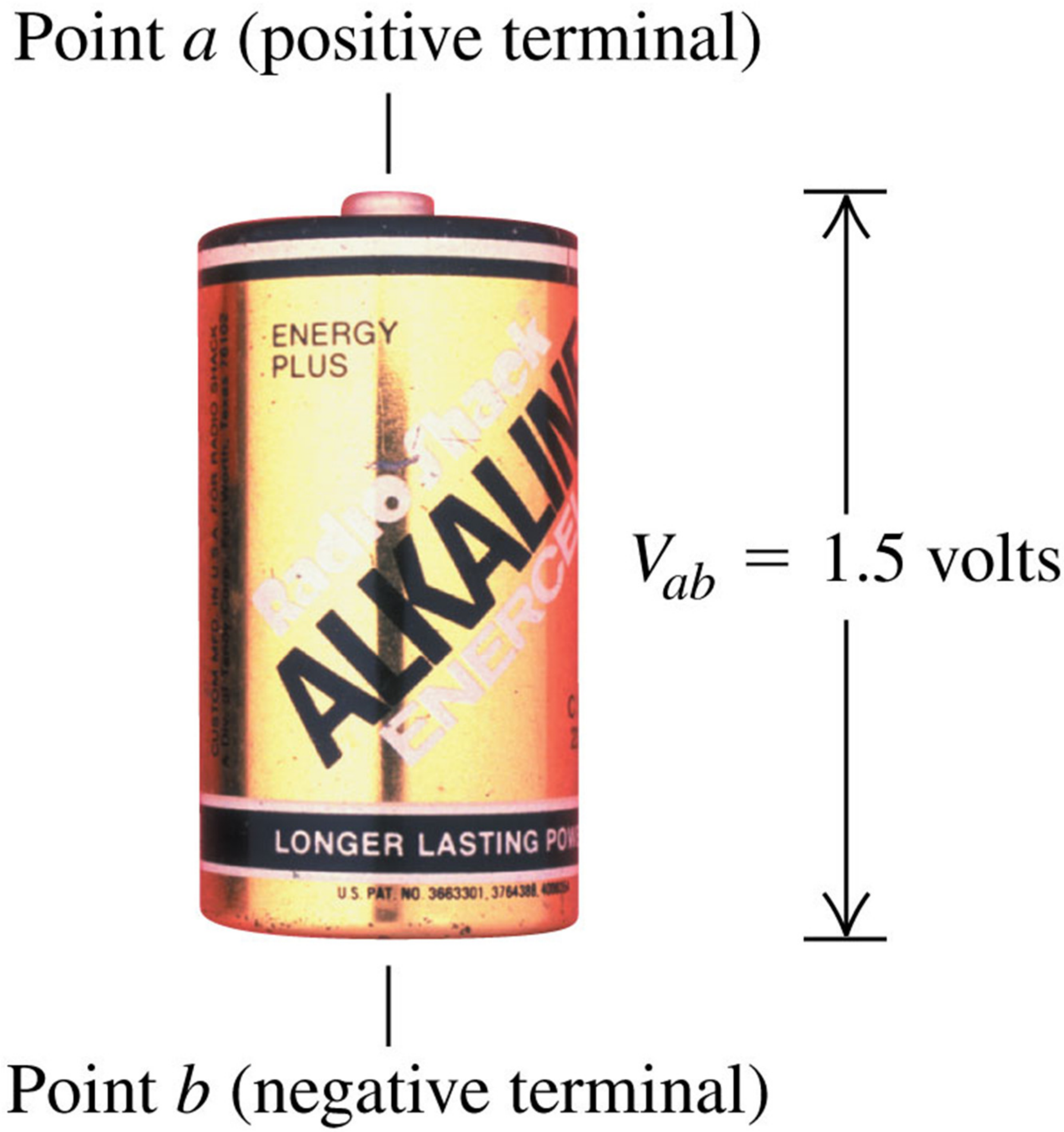


$$\Delta V = V_f - V_i = \frac{U_f}{q_0} - \frac{U_i}{q_0} = \frac{\Delta U}{q_0} = -\frac{W}{q_0}$$

V is in Volts J/C

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

$E = N/C$



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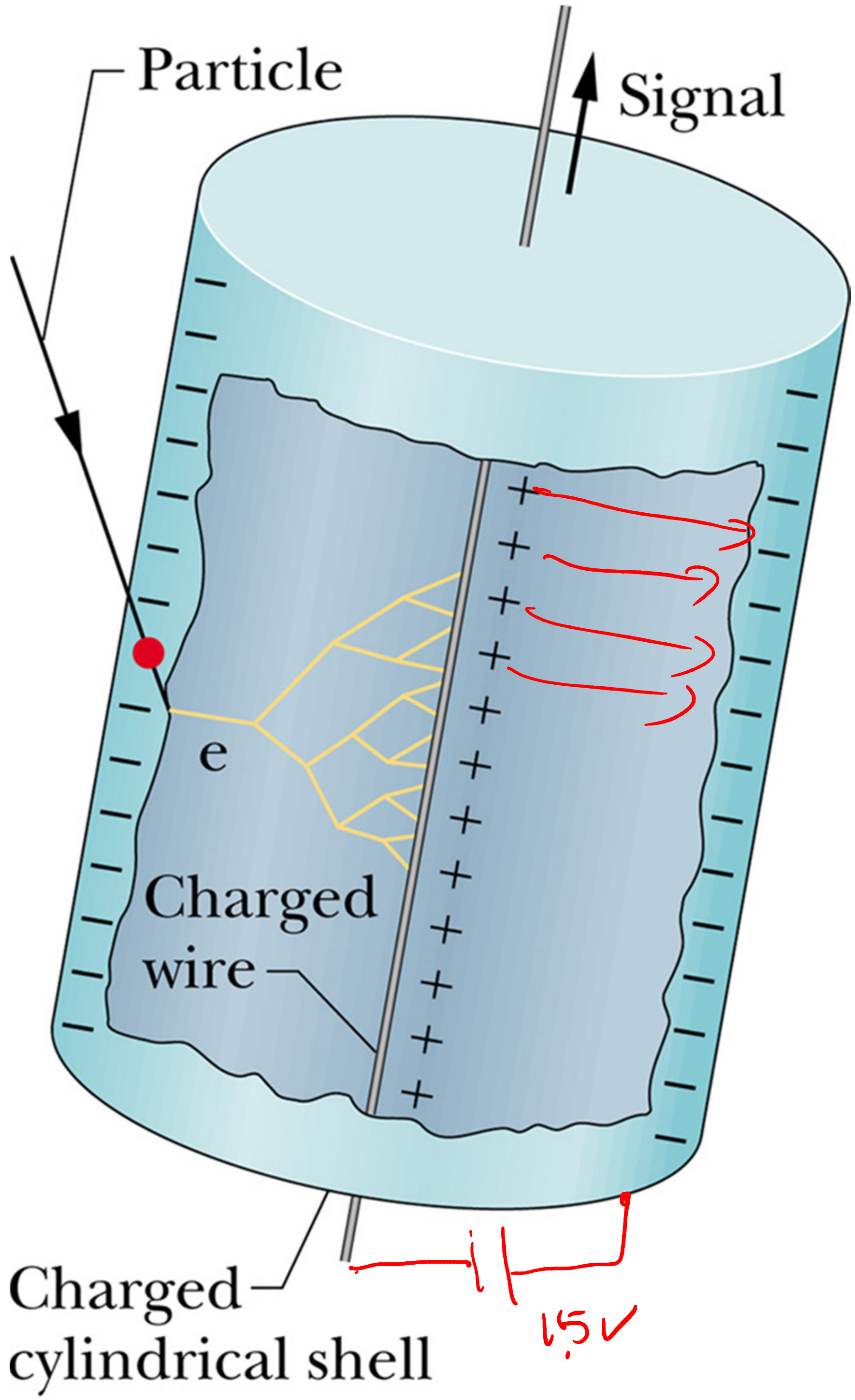


$V = 1.5V$

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

$= 1.5 eV$

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

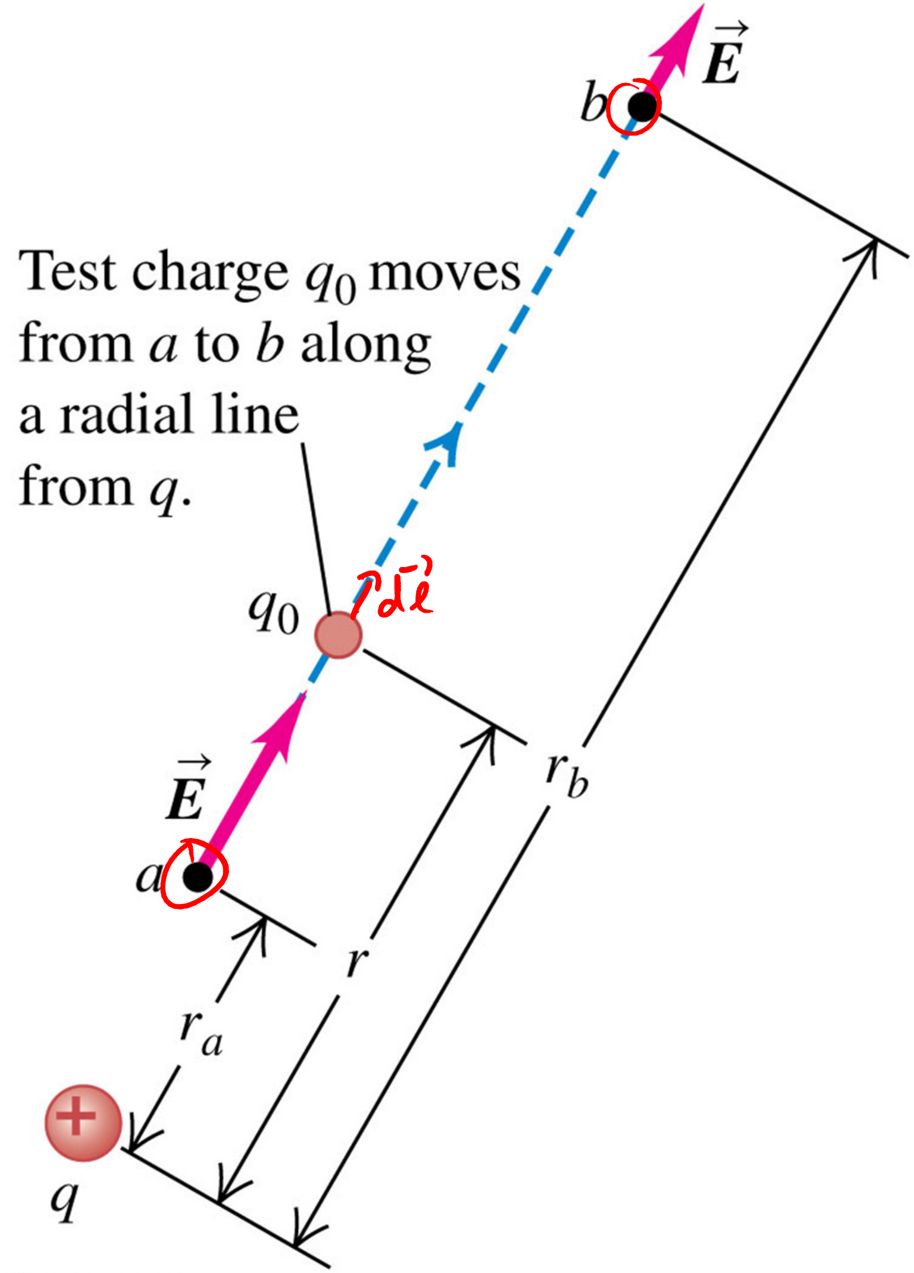
Look @ x-ray machine

80kV

beam of e^- across 80 kV = 80 keV

Worksheet time:
Work done by an electric field…

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



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

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

$W_{a\to b} = \int_a^b |\vec{F}||d\vec{l}| \cos 0$

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

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

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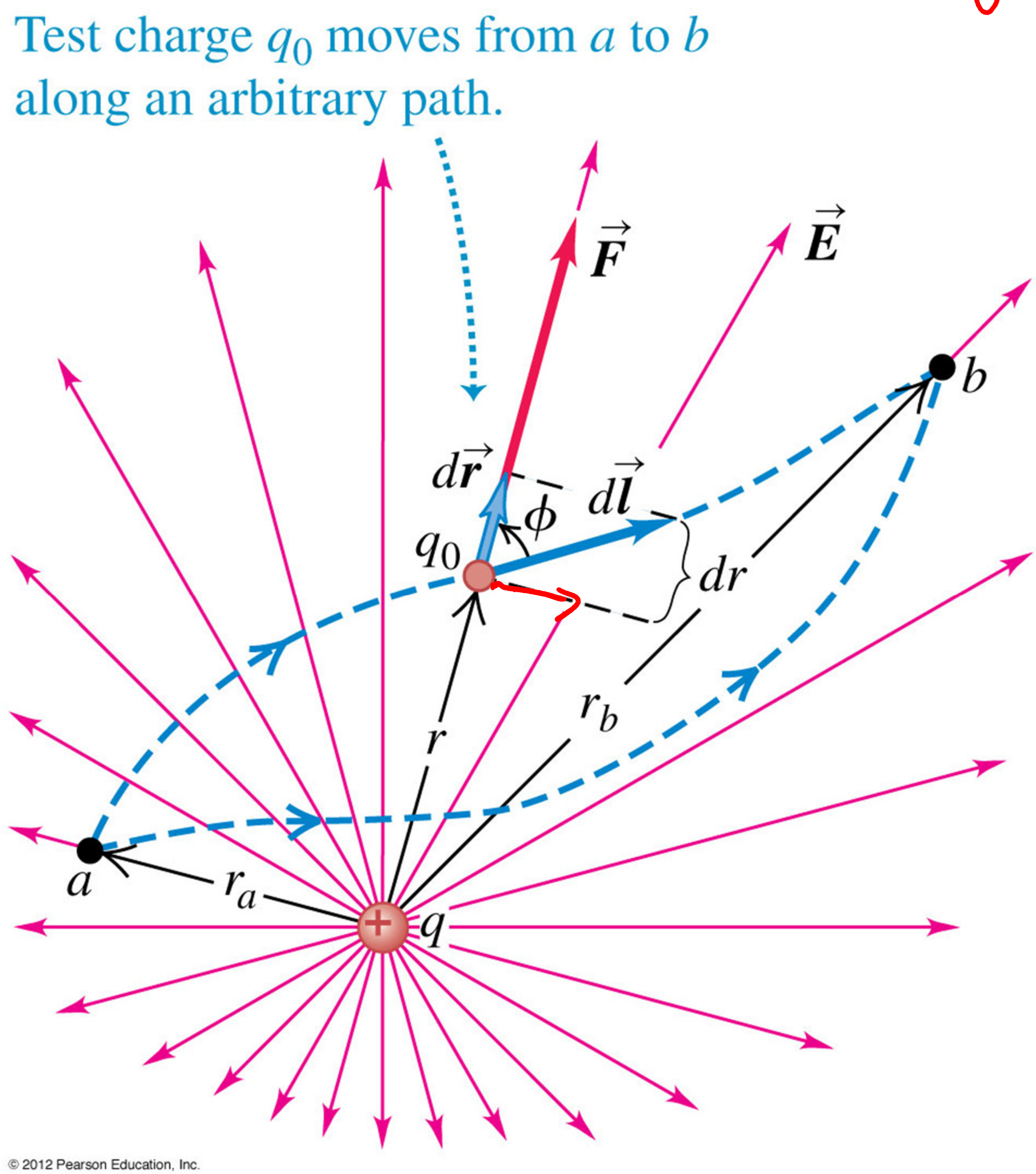


$$dW = \vec{F} \cdot dl$$

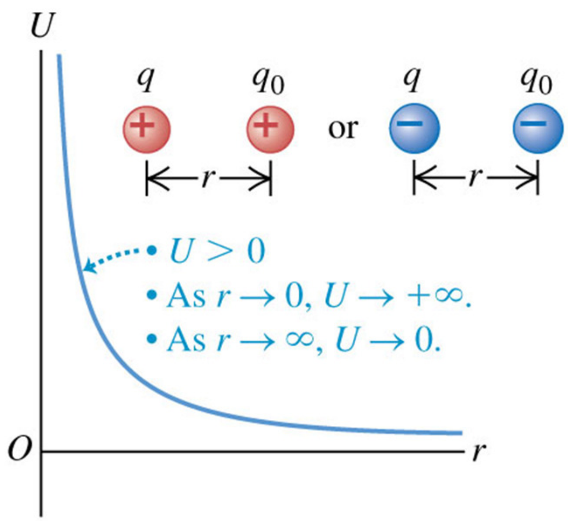
$$= |F| \, dl \cos\theta$$

$$dl \cos\theta = dr$$

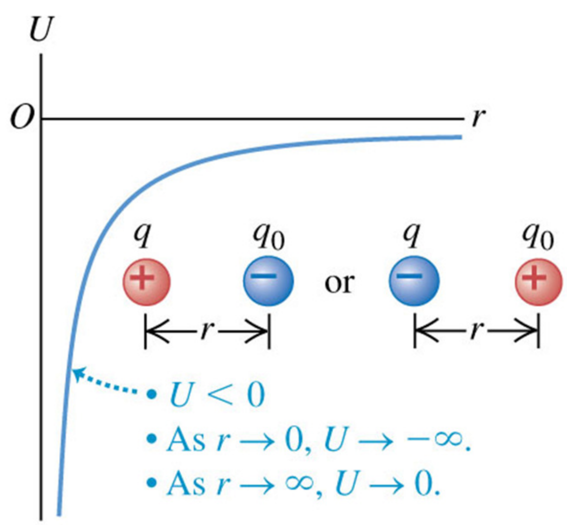
Only radial path matters

$$-W = \Delta U$$

(a) q and q_0 have the same sign.



(b) q and q_0 have opposite signs.



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

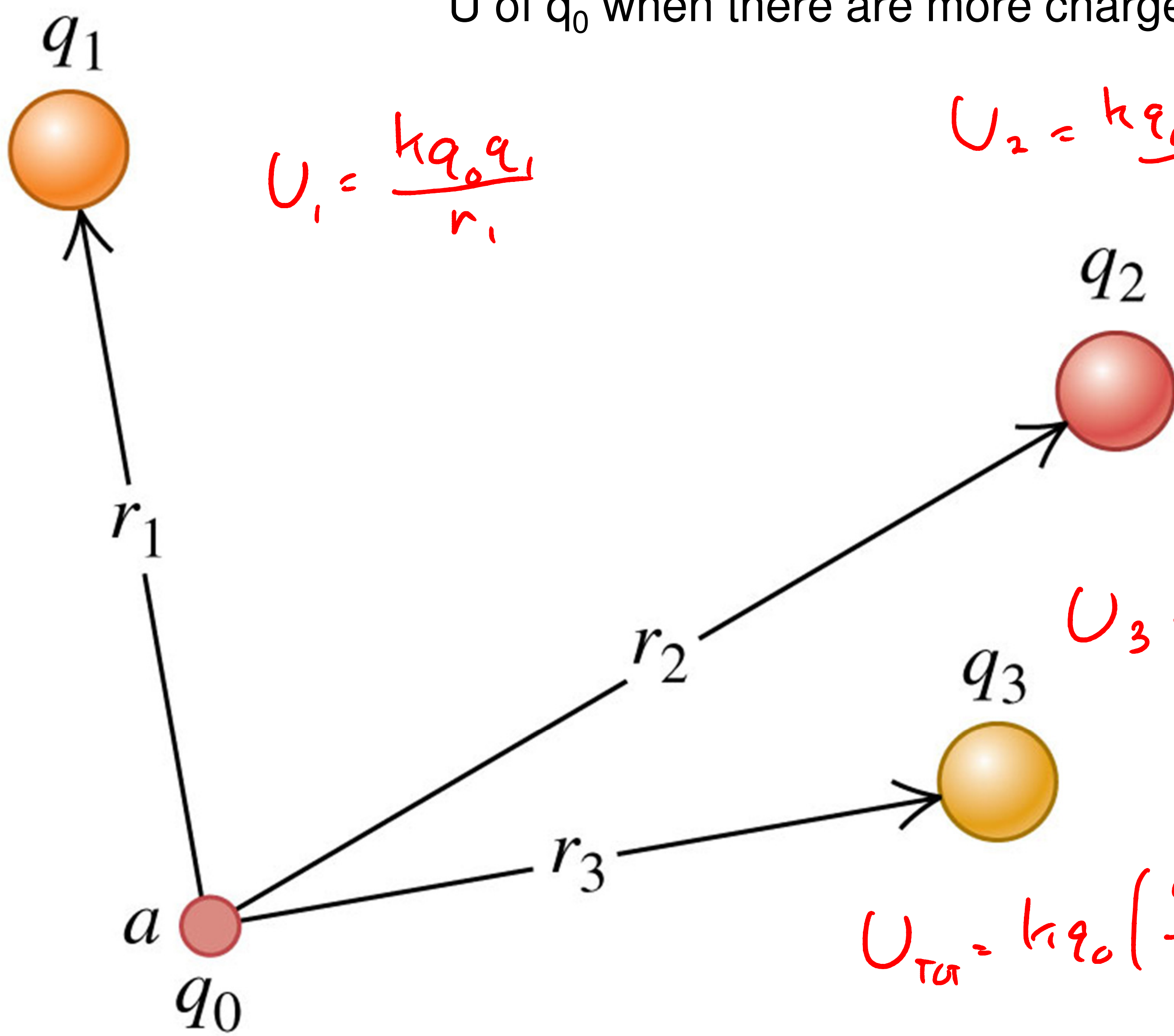
We can pick a "zero"…

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

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

$r = \infty$, $U = 0$

U of q_0 when there are more charges?



$$U_1 = \frac{k q_0 q_1}{r_1}$$

$$U_2 = \frac{k q_0 q_2}{r_2}$$

$$U_3 = \frac{k q_0 q_3}{r_3}$$

$$U_{TOT} = k q_0 \left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} \right)$$

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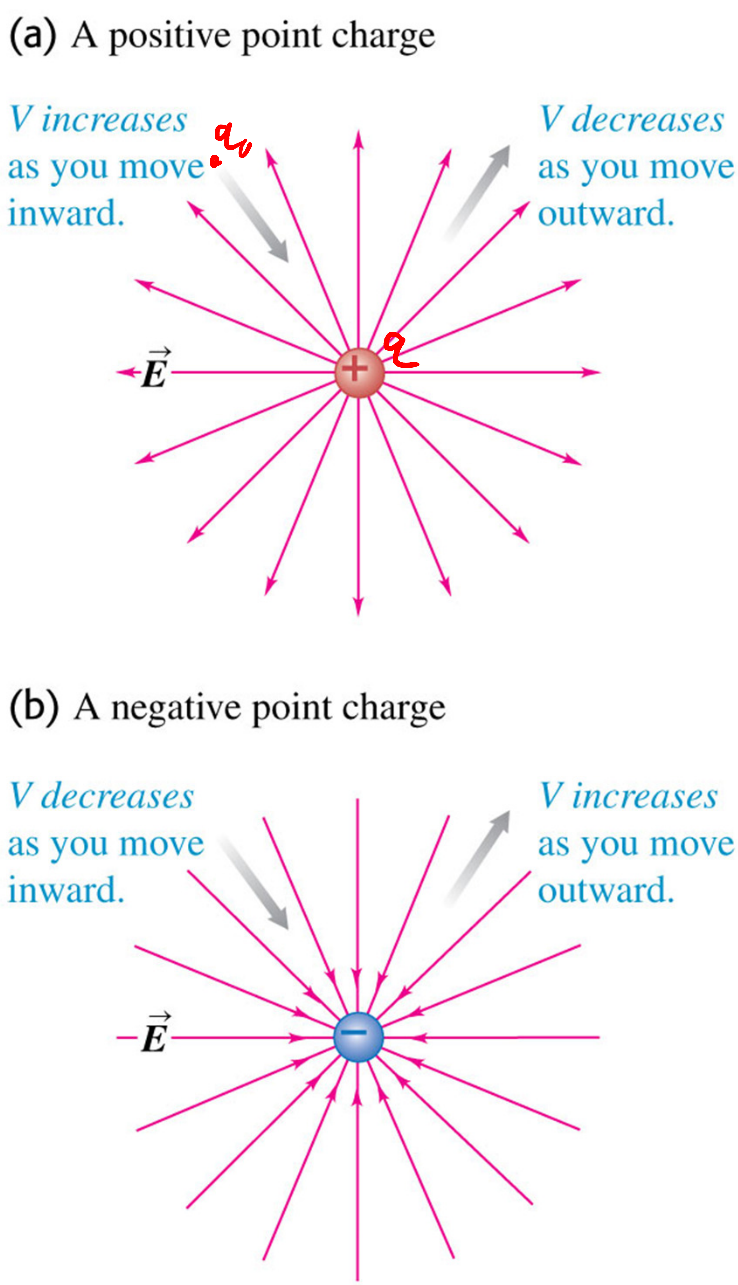

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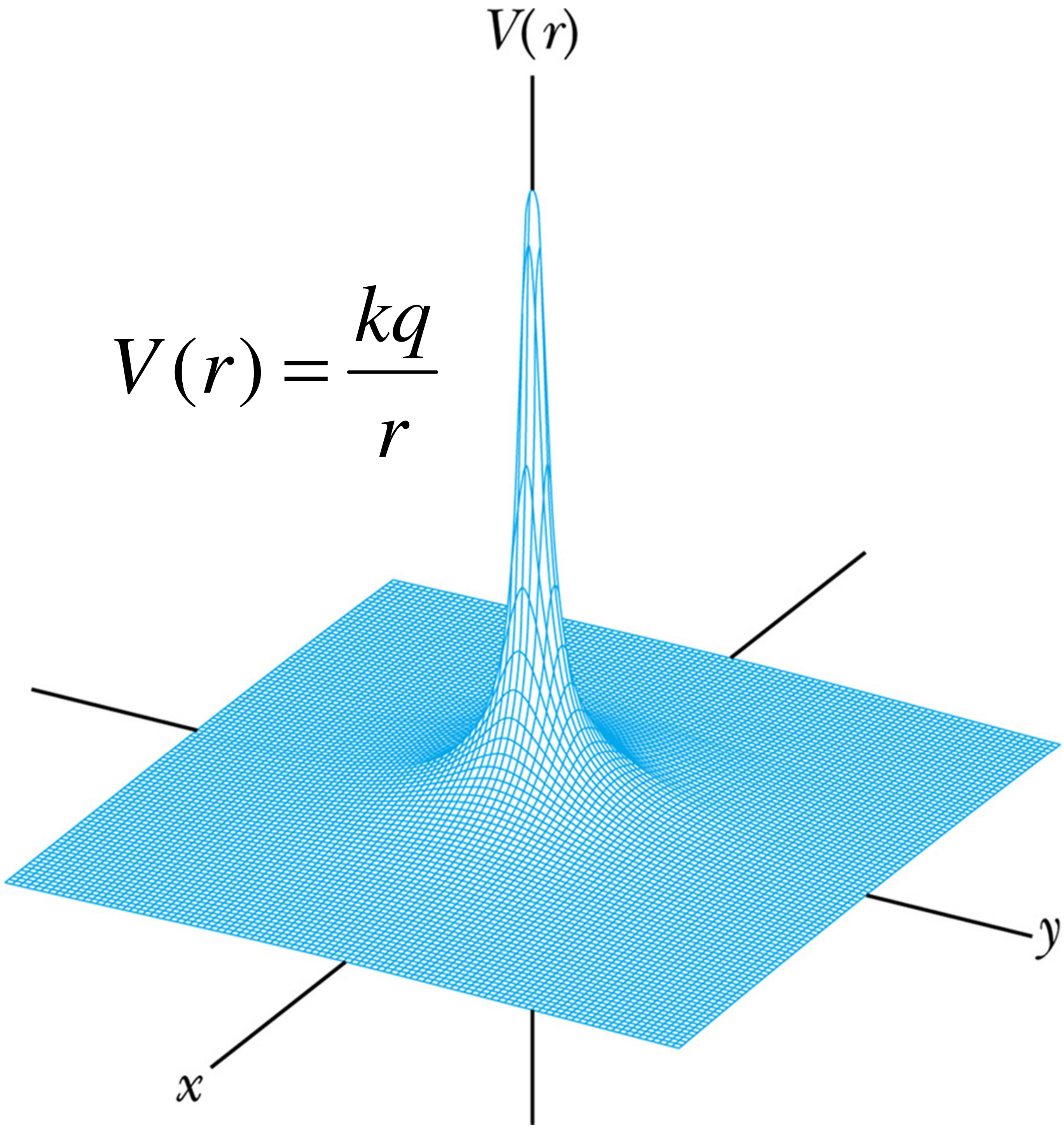
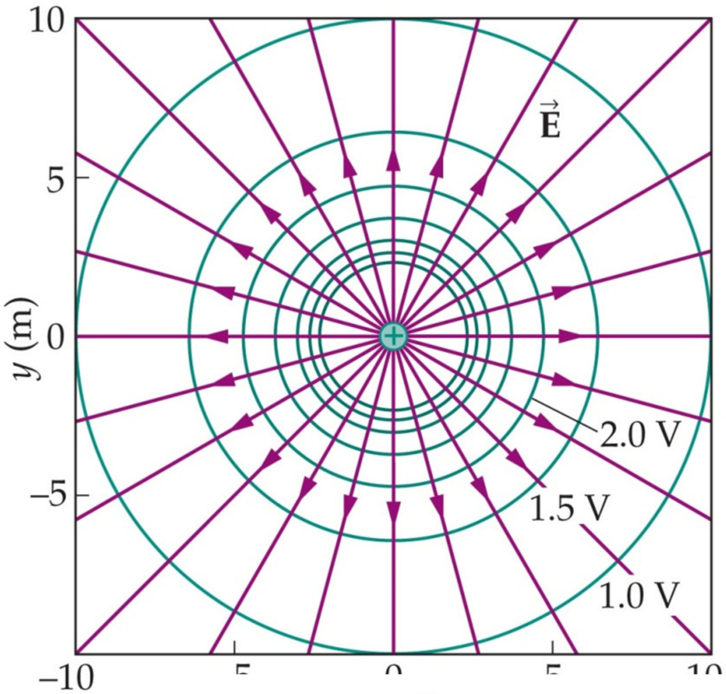
$$V = U/q_0 = \frac{\frac{k q_0 q}{r}}{q_0}$$

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

$$V(\infty) = 0$$



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



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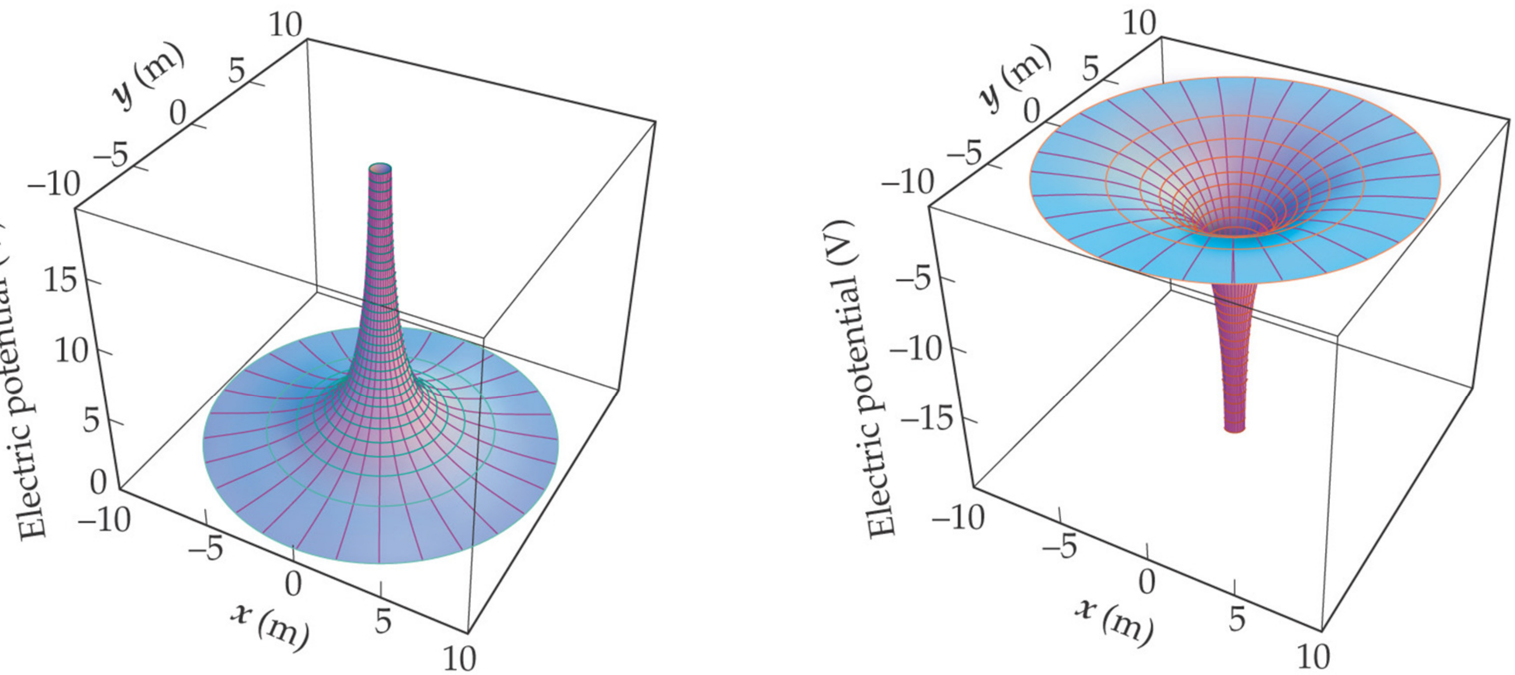
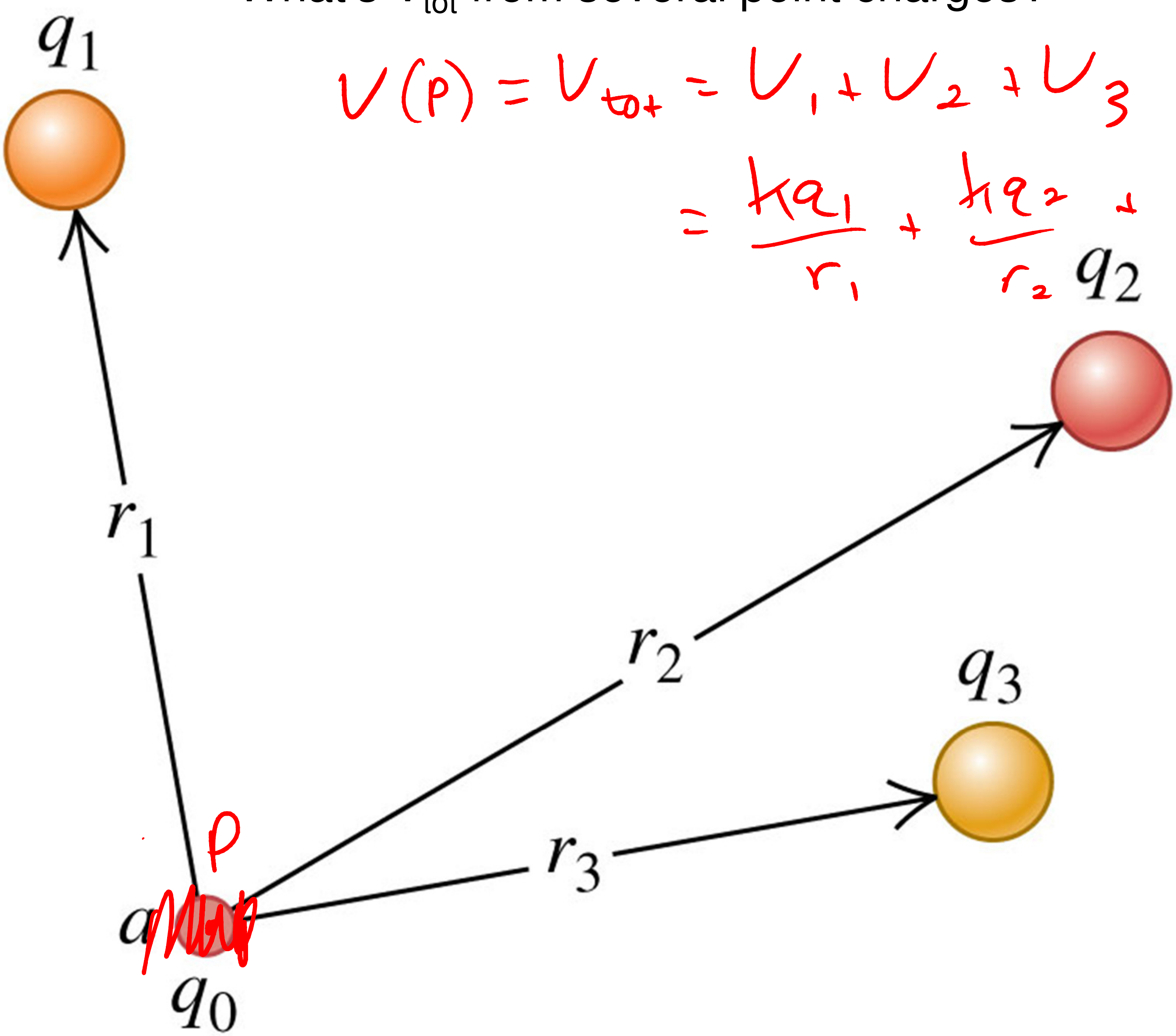


(a) **(b)**

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

$$V(P) = V_{tot} = V_1 + V_2 + V_3$$

$$= \frac{kq_1}{r_1} + \frac{kq_2}{r_2} + \frac{kq_3}{r_3}$$



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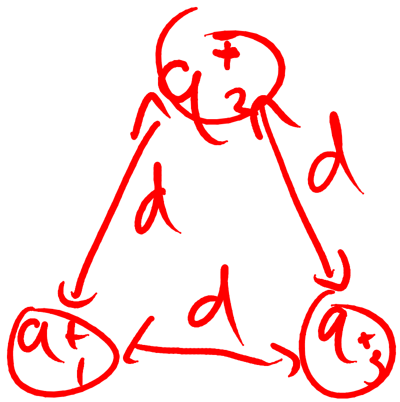

U of this collection?

$U_{\text{of a charge}} = q_{\text{of that charge}} V_{\text{at that place}}$

So: $U_1 = q_1 V_1$

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

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

like wise for U_2, U_3

Total $U = U_1 + U_2 + U_3$