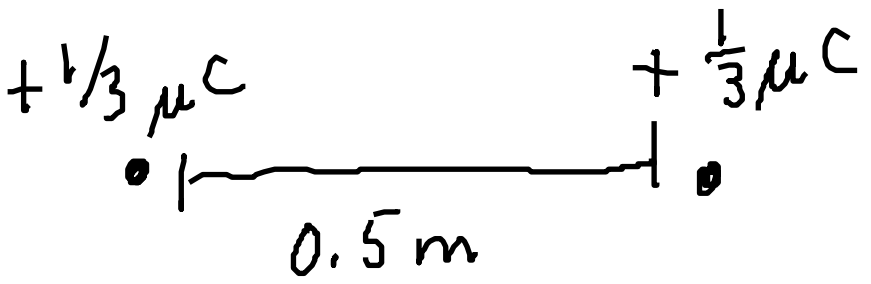


$$PE = k\frac{q_1 q_2}{d} + PE_\infty$$

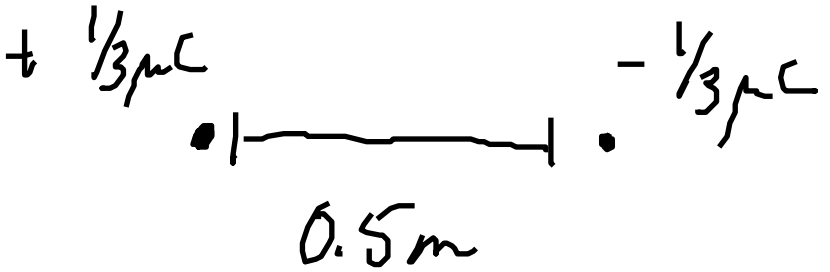
$k = 9\times10^9$ $\qquad$ $PE_\infty = 0$

$$PE = (9\times10^9)\frac{(\frac{1}{3}\times10^{-6})(\frac{1}{3}\times10^{-6})}{0.5\,m}$$

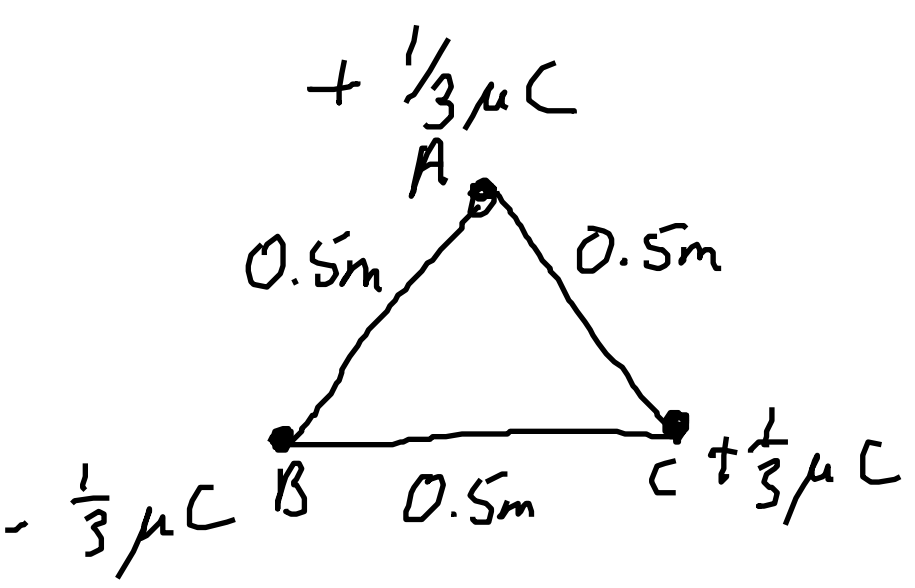
$$= 2\times10^{-3}\,J = 2\,mJ$$

$$\vec{F} = k\frac{q_1 q_2}{d^2}\hat{d} = \frac{(\frac{1}{3}\times10^{-6})(\frac{1}{3}\times10^{-6})}{(0.5)^2}(9\times10^9)$$

$$= 4\,mN$$



$$PE = -2mJ$$



Each pair of charges has an energy

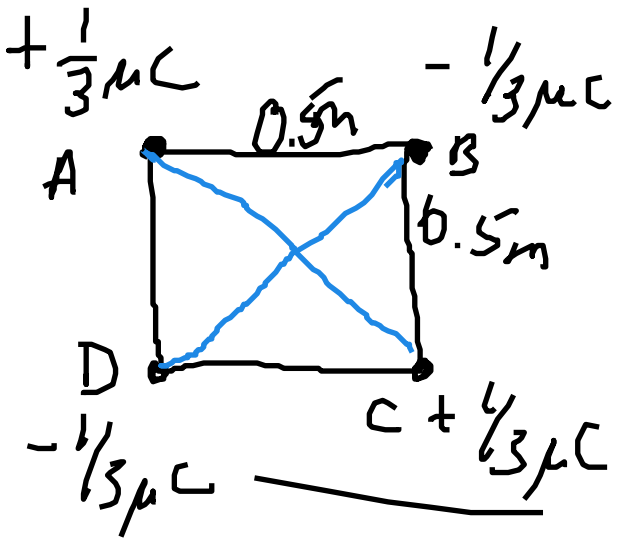
AB: $-2mJ$

BC: $-2mJ$

AC: $+2mJ$

PE: $-2mJ$

this only works if $PE_\infty = 0$



AB: $-2\,mJ$

AC: $+1.4\,mJ$

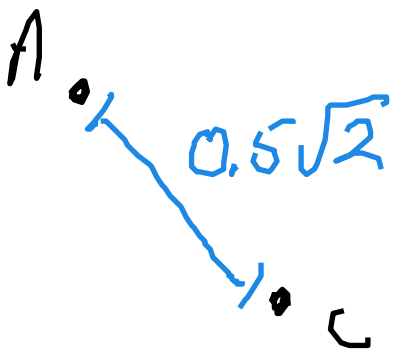
AD: $-2\,mJ$

BC: $-2\,mJ$

BD: $+1.4\,mJ$

CD: $-2\,mJ$

$-5.2\,mJ$



$$(9\times10^{9})\frac{\left(\frac{1}{3}\times10^{-6}\right)\left(\frac{1}{3}\times10^{-6}\right)}{0.5\sqrt{2}}$$

$$\frac{2}{\sqrt{2}}\,mJ$$

$\sqrt{2}\,mJ$

$1.4\,mJ$

If D is a target charge

A + −B sources

−D target +C

If sources don't move during the course of the problem, then their energy is irrelevant

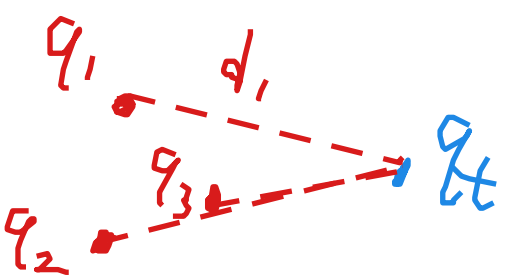
If target moves, only the energies depending on target matter

$$PE = PE_{AD} + PE_{BD} + PE_{CD}$$

$$= -2mJ + 1.4mJ - 2mJ$$

$$= -2.6mJ$$

In a source-target situation,
we can say here that
"charge D has PE of
$-2.6\,mJ$"



In general

$$PE_t = k\frac{q_1 q_t}{d_1} + k\frac{q_2 q_t}{d_2} + k\frac{q_3 q_t}{d_3} + \cdots + PE_\infty$$

$$= q_t\left(k\frac{q_1}{d_1} + k\frac{q_2}{d_2} + k\frac{q_3}{d_3} + \cdots\right) + PE_\infty$$

electric potential at location of the target

$$PE = q_t V$$

electric potential

$$V = \frac{PE}{q_t} \leftarrow$$ energy a charge q_t would feel at a particular location

$$= \frac{1}{q_t}\left[k\frac{q_1 q_t}{d_1} + k\frac{q_2 q_t}{d_2} + \cdots + PE_\infty \right]$$

$$= k\frac{q_1}{d_1} + k\frac{q_2}{d_2} + \cdots + \frac{PE_\infty}{q_t}$$

$$V = k\frac{q_1}{d_1} + k\frac{q_2}{d_2} + \cdots + V_\infty$$

arbitrary constant

Three pitfalls

1) Name

"electric potential" V ← defined for every location

vs

"electric potential energy" PE ← defined for single targets or pairs of charges

2) Units $\frac{J}{C} = \text{Volt}\ (V)$

variable symbol → $\bar{V} = 5\,\bar{V}$ ← unit

3) Only differences in electric potential are physically significant

"Potential difference" $\Delta V = V_f - V_i$

$\Delta V = IR$

"voltage" almost always means ΔV