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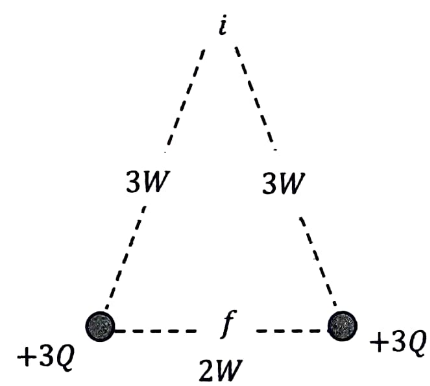
After this activity you should know: *• Relation between electric voltage and electric potential energy. • Use electric potential to solve conservation of energy problems. • Find the potential difference created by a uniform electric field. • The direction charges would move if release from rest in regions of changing potential.*

1. Two charges are separated by the distance $2W$ shown. We want to find the voltage due to these charges at point i and at point f (which is midway between the two charges).

   a. What is the voltage at point i? Take $V = 0$ at ∞.

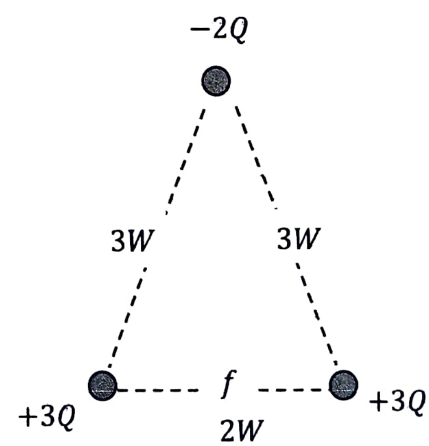


$$2 \cdot \frac{\cancel{3}kQ}{\cancel{3}W} = \frac{2kQ}{W}$$

   b. What is the voltage at point f?

$$2 \cdot \frac{3kQ}{W} = \frac{6kQ}{W}$$

   c. A third charge $-2Q$ with mass M is released from rest at point i as shown. What is the change in potential energy during this process? Assume that the $+3Q$ charges are much more massive so they do not move and that no other forces act on $-2Q$.



$$\Delta U = q\,\Delta V$$

$$-2Q \cdot \frac{4kQ}{W} = \frac{-8kQ^2}{W}$$

   d. How fast is this new charge moving when if reaches point f?

$$\frac{\cancel{2}}{m}\left(\frac{1}{\cancel{2}}\cancel{m}v_f^2 = +2\left(+\frac{8kQ^2}{W}\right)\right)$$

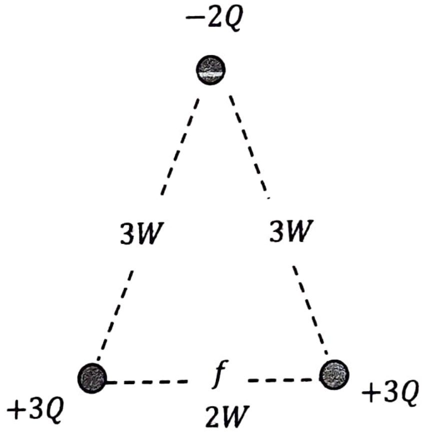
$$v_f = \sqrt{\frac{16kQ^2}{mW}}$$

2. The electric potential energy stored in a group of point charges is given

$$U = \sum_{all\,pairs} K\frac{q_i q_j}{r_{ij}}$$

where r_{ij} is the distance between the ith and jth charge and the sum is over all ways to pair the charges. The potential energy is taken to be zero when all the charges are infinitely far apart. Note that the potential energy is a scalar but may be positive or negative.

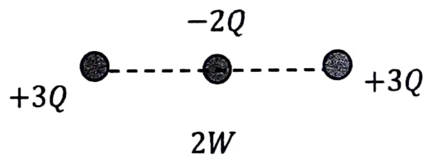
a. Determine the electrical potential energy of the system of three charges when the -Q chaDetermine the potential energy of the system of three charges when the -Q charge is at initial position shown.



$$K\left(\frac{-6Q^2}{3w}+\frac{-6Q^2}{3w}+\frac{9Q^2}{2w}\right)$$

$$K\left(-\frac{12Q^2}{3w}\cdot\frac{2}{2}+\frac{9Q^2}{2w}\cdot\frac{3}{3}\right) = K\cdot\frac{1\cancel{7}Q^2}{2\cancel{6}w}$$

b. Determine the potential energy of the system of three charges when the $-2Q$ charge is at the final position shown.



$$K\left(\frac{-6Q^2}{w}+\frac{-6Q^2}{w}+\frac{9Q^2}{2w}\right)$$

$$K\left(\frac{-12Q^2}{w}\cdot\frac{2}{2}+\frac{9Q^2}{2w}\right) = -K\cdot\frac{15Q^2}{2w}$$

c. Use your result from (a) and (b) to find the change in potential energy as the $-2Q$ charge moves from the initial to final position.

$$-\frac{15}{2}\frac{KQ^2}{w} - \frac{1}{2}\frac{KQ^3}{w} \qquad -\frac{8KQ^2}{w}$$

d. Check that your answer agrees with your result from 1c. Why is it easier to use $\Delta U = q\Delta V$ for this case?

Because it does not rely on the position of the charge.