Problem 15.54

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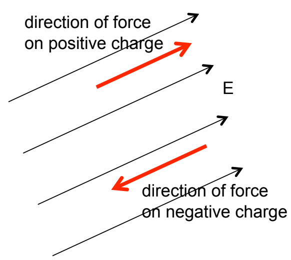
$$\sum KE_1 + \sum U_1 + \sum W_{ext} = \sum KE_2 + \sum U_2$$

$$K \quad + \quad 0 \quad + \vec{F}_e \bullet \vec{d} \quad = \quad 0 \quad + \quad 0$$

$$\Rightarrow \quad K + \left(q\vec{E}\right) \bullet \vec{d} \ = 0$$

This dot product is a little tricky. To determine the angle between the electric field E and d, where d is in the direction of the velocity vector, we need to think a little bit about how an electron behaves in an electric field, and about what THIS electron is doing in this problem.

The electric force on an electron in an electric field will be exactly opposite that of the electric force on a positive charge. (Remember, the direction of an electric field is defined as the direction of force on a positive charge in the field, so the direction of force on an electron will be OPPOSITE the electric field direction.)



If the electron is moving OPPOSITE the direction of an electric field (i.e., in the direction of the force on it), it will speed. If the electron is to slow down, it must be moving WITH the electric field.

That means the angle between E and d must be zero and the dot product will, due to its cosine factor, be positive.

But we KNOW the work being done on the electron must be negative as it's slowing down, so where does the negative sign come from? It comes from the fact that the electron feeling the force is negative. That is, q = -e = -1.6x10^-19 for an electron. That is where the negative sign comes from. Mathematically, this can be written as:

$$K + (-eE)\,d\cos\left(0^\circ\right) \ = 0$$

$$\Rightarrow \quad E = \frac{K}{ed}$$