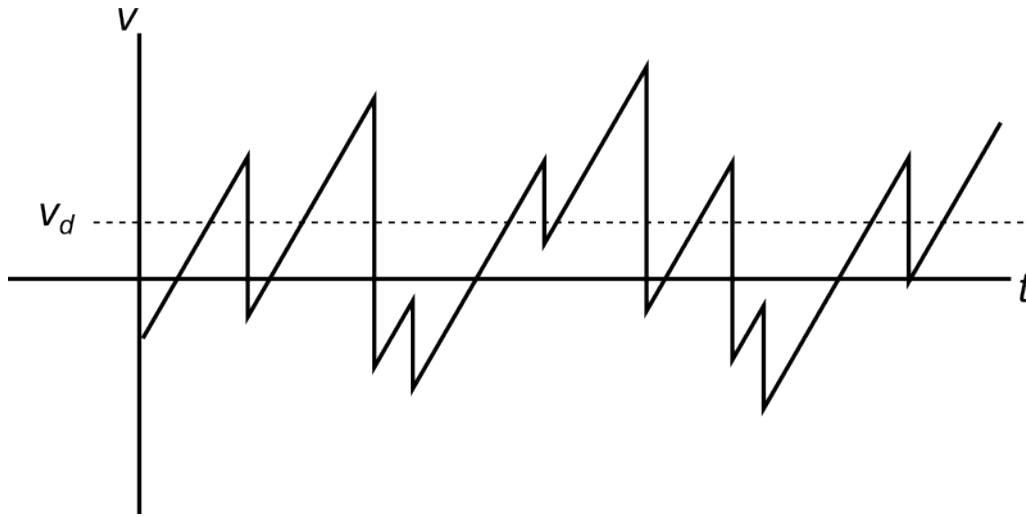


Ohm's law

We have seen that a current in a wire is a result of electrons that are responding to the electric field that is set up when there is a potential difference between the two ends of the wire. The electrons are bouncing around as they travel and between collisions they are continually accelerating in the direction of the force. The v vs t graph for an electron (in the direction of the force) will look like the following:



It is apparent from this picture that the average velocity, or drift velocity, will depend on the electron's acceleration between collisions and the time between collisions. The acceleration will be proportional to the strength of the electric field. It turns out that the time between collisions depends on the material, the temperature, and other factors associated with the wire, and can be captured in a quantity known as the electron mobility, μ (yes, I know we used that symbol lots of different times to mean different things), which relates the drift velocity to the electric field strength:

$$v_d = \mu E$$

If we go back to our model of a straight wire of length l with a potential difference ΔV between the two ends, then:

$$v_d = \mu \ell \Delta V = \frac{I}{neA}$$

and we find that the current through a wire of length l cross sectional area A , with a potential difference ΔV between the ends will be:

$$I = \mu ne \frac{A}{\ell} \Delta V = \frac{1}{\rho} \frac{A}{\ell} \Delta V = \frac{1}{R} \Delta V$$

This is Ohm's law: the current through a wire is proportional to the voltage across it! The resistance R depends on the resistivity of the material ρ , the cross sectional area of the wire and its length. It is easy to obtain resistivity values for various materials from many sources.

What about resistors? We've talked only about wires. Well, a resistor is just a wire with a large resistance (large ρ and/or large l and/or small A).