If we move a conductor through a magnetic field, there will be an EMF (voltage) established across the conductor:

$$E = Blv$$

- $E$: EMF induced
- $B$: field strength
- $l$: Length of the conductor perpendicular to direction of motion
- $v$: velocity of conductor

This equation can be proven in two ways: Using Faraday's Law ($E = -N \frac{\Delta \Phi}{\Delta t}$) or by using the force on charged particles in a $B$ field.

**Basic Picture**
**E** moving conductor = $BLv$ Method #1 - Faraday's Law

From Example #2b on Page 6 of the notes titled “Faraday's Law of Induction”, we saw that by moving a loop out of a magnetic field, we can decrease the exposed area, therefore decreasing the flux:

$$E = \frac{\Delta \Phi}{\Delta t} = \frac{B \cdot \Delta A}{\Delta t} = \frac{B \cdot l \cdot v \cdot \Delta t}{\Delta t} = Blv$$

$$A = l \cdot x = l \cdot v \cdot \Delta t$$

**E** moving conductor = $BLv$ Method #2 - $F_{charge} = qvB \sin \theta$

On the first day of this unit, we learned that a moving charge experiences a force when in a $B$ field

$$F_B = qvB$$

Since the entire wire contains electrons, they are all moving with the wire. This forces the negative electrons to flow to the bottom of the wire, according to the right hand rule.

The charges will move until the magnetic force ($F_B = qvB$) balances the electric force of attraction ($F_E = qE$) between the charges.
\[ \vec{F}_e = \vec{F}_E \]
\[ q\vec{v}_B = q\vec{E} \]

By cancelling out the charges, we are left with an expression for the strength of the \( \vec{E} \) field in terms of the \( \vec{B} \) field:

\[ \vec{v}_B = \vec{E} \]

Remembering that voltage \( (\mathcal{E}) \) is the \( \vec{E} \) field strength times the separation distance between them, which is, in this case, the length of the wire \( (L) \), \( \mathcal{E} \) is:

\[ \mathcal{E} = \mathcal{E}d = \mathcal{E}L = \vec{v}_B L \]

\[ \therefore \boxed{\mathcal{E} = BLv} \]

Example: Moving a wire to create current

One of the most useful applications of this equation is in creating current flow with a moving wire, aka. a generator. In fact, almost all of the electricity produced in the world (with exception of solar panels and a few other very minor sources) is produced in this way.
All it takes is a magnetic field ($\mathbf{B}$) and a wire of length $l$, moving at a speed of $v$.

$$E = Blv$$

$$I_{\text{induced}} = \frac{E}{R}$$

$$I = \frac{Blv}{R}$$

In this case, $R_{\text{load}}$ is whatever we are trying to power with the generator, whether it be a submersible pump to dry out the basement after a flood, or the entire Midwest region.

If we want to power more stuff, we either need more wire, a stronger $\mathbf{B}$ field, or to move the wire faster.

$$\therefore E = Blv$$, the fundamental equation upon which your quality of life depends.