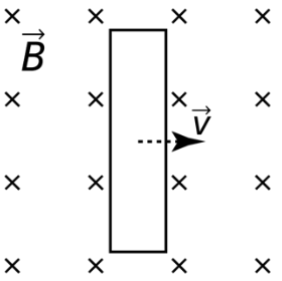
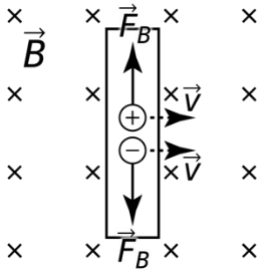
Flipping Physics Lecture Notes:
Motional EMF via Newton's Second Law
http://www.flippingphysics.com/motional-emf-newton.html

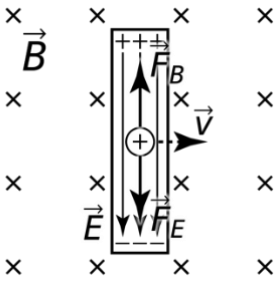
Motional emf is the idea that the motion of a conductor moving in a magnetic field can cause charges to move in the conductor creating a voltage across the conductor. In other words, a conductor moving in a magnetic field can acquire an induced emf across it.



- The conductor is moving to the right with a constant velocity at a right angle to a magnetic field which is into the page.
- According to the right-hand rule, positive charges will experience an upward magnetic force, and negative charges will experience a downward magnetic force.
- This will result in the movement of charges with the final result being that there will be a net positive charge on the top end of the conductor and a net negative charge on the bottom end of the conductor. This arrangement of charges creates a uniform, downward electric field in the moving conductor.



- As a result of the downward electric field in the conductor, positive charges will experience a downward electrostatic force, and negative charges will experience an upward electrostatic force.



- Because the conductor is moving at a constant velocity, the charges will arrange themselves such that equilibrium is reached between the magnetic and electric forces acting on the charges such that the electric field has a constant magnitude and the charges in the conductor are moving with a constant velocity to the right; there is no vertical motion of the electric charges.
- We can now sum the forces on a positive charge.
  - The same final equation is derived when using a negative charge.

$$\sum \vec{F}_y = F_B - F_E = ma_y = m(0) = 0 \Rightarrow F_B = F_E \Rightarrow qvB\sin\theta = qE$$

$$\Rightarrow vB\sin 90^\circ = E \Rightarrow vB = E$$

Previously we derived the equation relating voltage and a uniform electric field. We have already identified the direction of the electric field, so we only need the absolute value of the voltage.

$$\& \ \Delta V = -Ed \Rightarrow |\Delta V| = EL \Rightarrow E = \frac{\Delta V}{L} = vB \Rightarrow \Delta V = vBL \Rightarrow \varepsilon = vBL$$

L is the length of the conductor. We have derived the voltage or the induced emf across the conductor moving at a right angle to a uniform magnetic field. This is called *motional emf*.