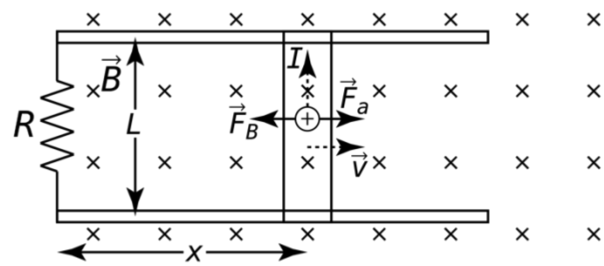
Flipping Physics Lecture Notes:
Motional EMF via Faraday's Law
http://www.flippingphysics.com/motional-emf-faraday.html

Previously we derived the motional emf equation using Newton's Second Law. There is actually an entirely different approach to deriving the same motional emf equation. This approach starts with a conductor moving to the right while in contact with two parallel, metal rails connected by a wire at the left end with a uniform magnetic field going into the page. The resistance of the circuit is represented by the resistor shown in the wire on the left. A force is applied to the conductor to cause it to move to the right. We can use Lenz' law to determine the direction of the induced current in the loop.



- The magnetic field is into the screen and the magnetic flux is increasing because the area of the loop is increasing which increases the number of field lines passing through the loop.
- The induced magnetic field opposes this change in flux and is directed out of the page.
- Using the alternate right-hand rule, our fingers curl in the direction of the induced magnetic field which is out of the page inside the loop and our thumb points in the counterclockwise direction which is in the direction of the induced current in the loop.
- Notice this means that, because positive charges are moving in the direction of conventional current in the conductor, we can use the right-hand rule to show that the fingers point in the direction of the motion of the positive charges which is up, fingers curl in the direction of the magnetic field, which is into the page, and our thumb points in the direction of the magnetic force, which is to the left. In other words, there is a magnetic force which opposes the motion of the conductor in the magnetic field. If the applied force is constant, the magnetic force will also be constant to keep the conductor moving at a constant velocity.
- Now we can use Faraday's law to determine the magnitude of the induced emf in the conductor.

$$\varepsilon = -N\frac{d\Phi_B}{dt} = -N\frac{dBA\cos\theta}{dt} = -(1)B\cos(180^\circ)\frac{d(Lx)}{dt} = BL\frac{dx}{dt}$$

$$\Rightarrow \varepsilon = vBL$$