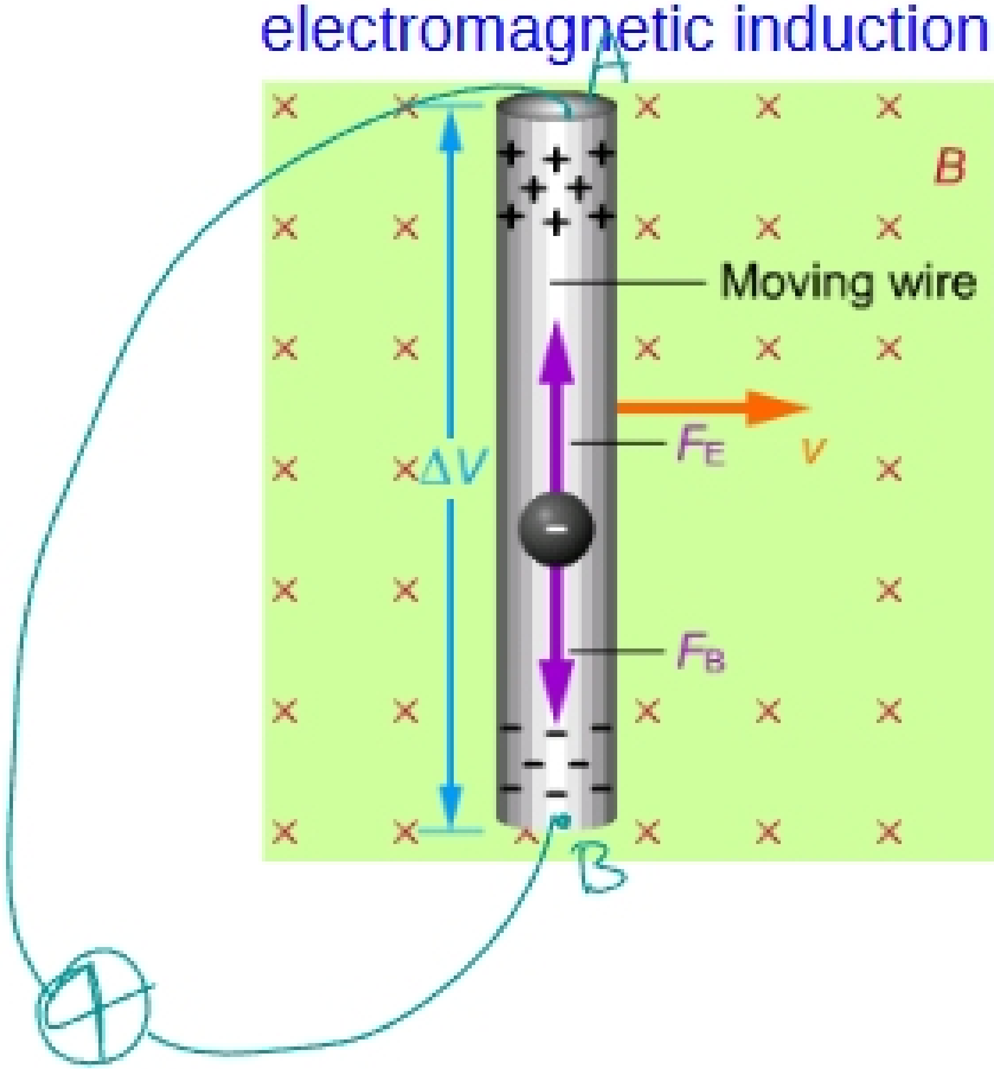
Electromagnetic Induction

- Moving charges inside a magnetic field experience magnetic force.
- This force will redistribute charges in a moving conductor so that an electric field will be established because of these displaced charges. This is called the motional electromagnetic induction.



$F_B = qvB$; $F_E = qE$, E comes from the displaced charges

$U_A - U_B = \Delta V = -EL$, when $F_B = F_E$, a stable potential difference ΔV from the ends of the moving conductor is established to be:

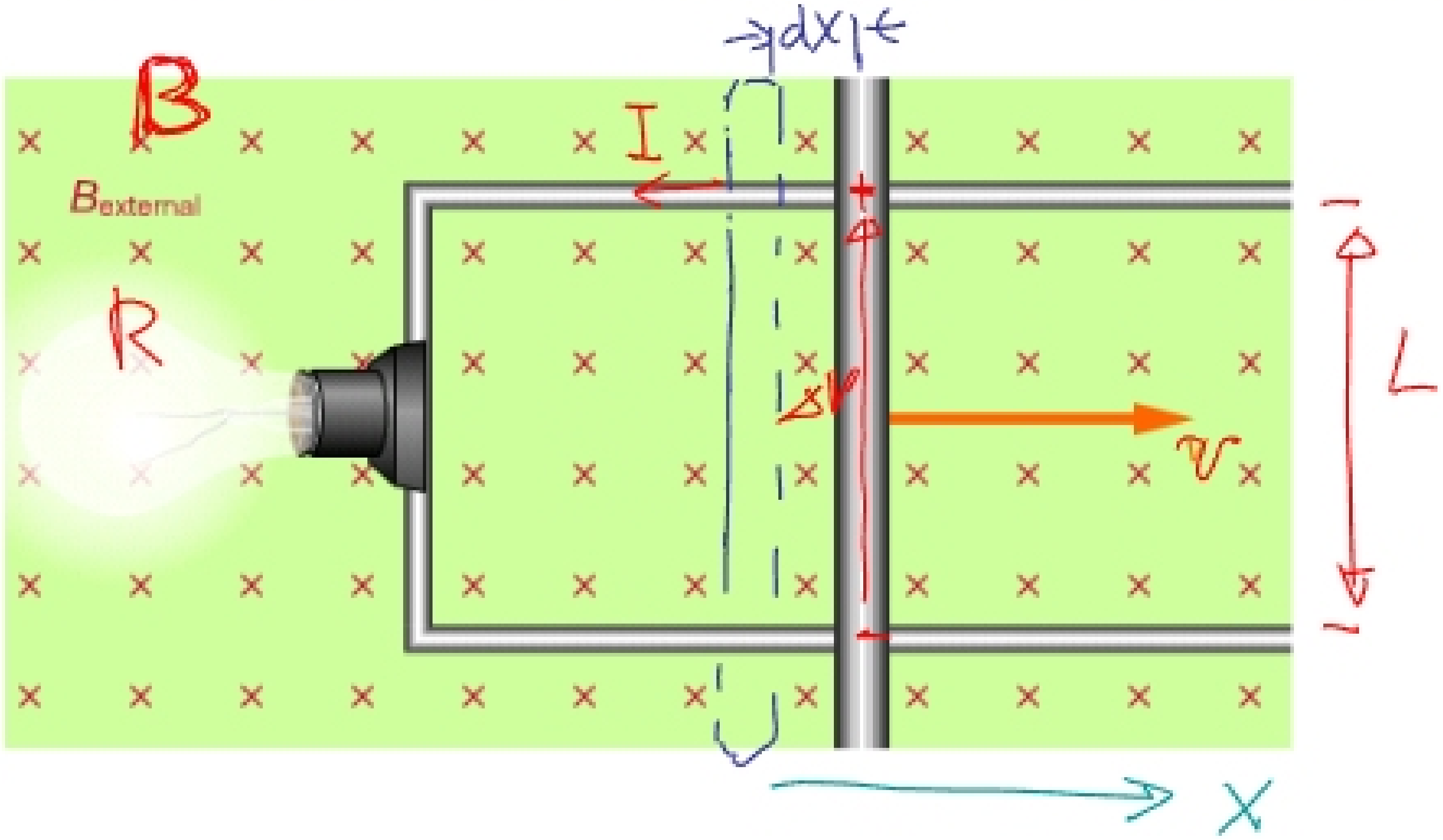
$qvB = qE = -\frac{\Delta V}{L}$, $\underline{\underline{\Delta V = -LvB}}$

or $|\Delta V| = LvB$

if we form a circuit with a lamp, the lamp will light up ?

ΔV = potential difference across wire
L = length of wire
v = speed
B = magnetic field strength

- Exam the motion induced emf from another perspective:



$$\Delta V = -LvB = \text{emf}$$

$$\text{so emf} = -LvB = -L\frac{dx}{dt}B = -\frac{L\,dx}{dt}B = -\frac{B\cdot dA}{dt}$$

Here $dA = dx \cdot L$ is the change in the enclosed area.

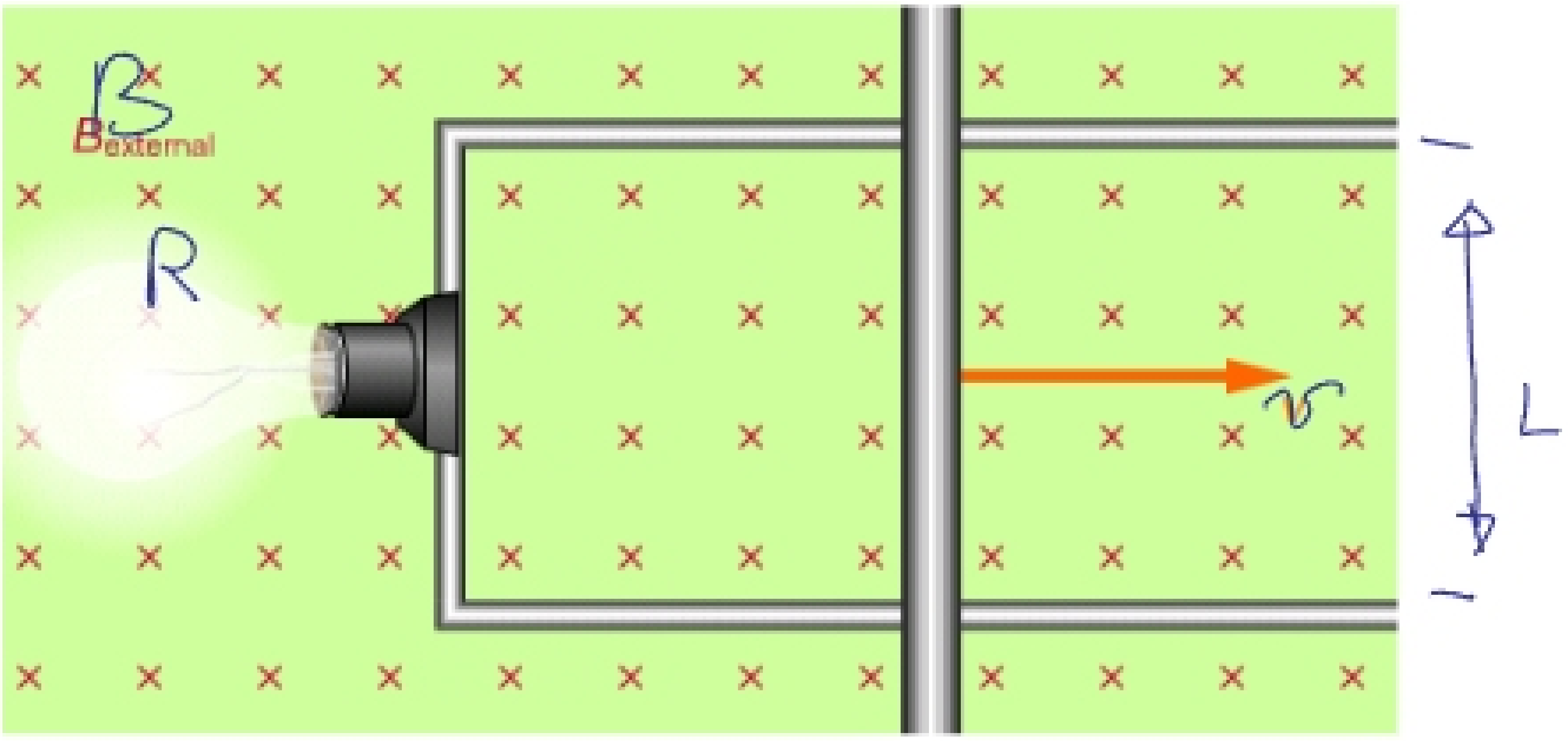
if we define a magnetic flux $\phi_B = \int_S \vec{B}\cdot d\vec{A}$, Here

in this case, B is a constant, so $\phi_B = \int_S B\,dA$, $d\phi_B = B\,dA$,

So $\text{emf} = -\dfrac{d\phi_B}{dt}$ $\Rightarrow$ this is Faraday's Law.

$emf = -\frac{d\Phi_B}{dt}$

Two examples



when $B = 0.1\,T$

$v = 30\,m/s$

$L = 1\,m$

$R = 1\,\Omega$

what is the power the resistor dissipates?

$$emf = |LvB| = 1m \cdot 30 m/s \cdot 0.1T = 3.0\,V$$

$$P_R = \frac{emf^2}{R} = \frac{(3.0)^2}{1} = 9\,W$$

If you pull on the moving bar to generate this power, what is the force you have to apply: $P = Fv$, $F = P/v = 9/30\,N$

The bar moves at a constant speed of 30 m/s, what is the force that balances on the force you apply?