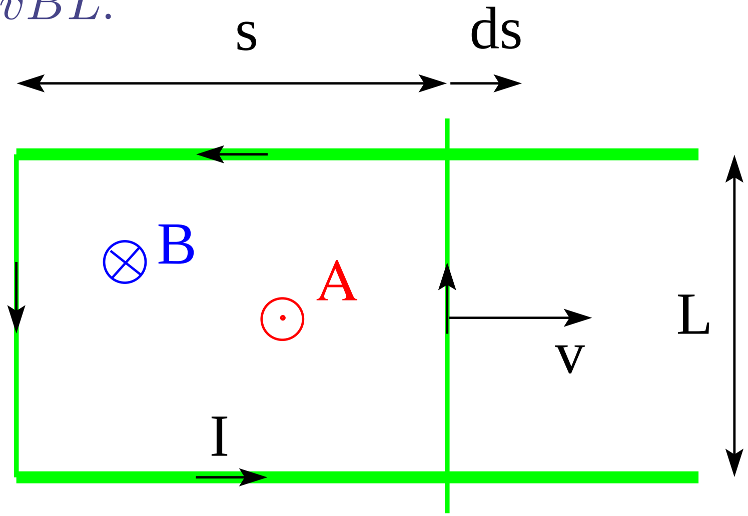
Faraday's Law of Induction (1)

Prototype: motional EMF reformulated.

- Choose area vector $\vec{A}$ for current loop: $A = Ls \ \odot$.
- Magnetic flux: $\Phi_B = \int \vec{B} \cdot d\vec{A}$. Here $\Phi_B = -BLs$.
- Motional EMF: $\mathcal{E} = vBL$.
- Change in area of loop: $dA = Lds$.
- Change in magnetic flux: $d\Phi_B = -BdA = -BLds$.
- SI unit of magnetic flux: 1Wb=1Tm^2 (Weber).
- Rate of change of flux: $\dfrac{d\Phi_B}{dt} = -BL\dfrac{ds}{dt} = -vBL$.
- Faraday's law: $\mathcal{E} = -\dfrac{d\Phi_B}{dt}$.



Faraday's Law of Induction (2)

Here the change in magnetic flux Φ_B is caused by a moving bar magnet.

- Assume area vector $\vec{A}$ of loop pointing right.
  Hence positive direction around loop is clockwise.
- Motion of bar magnet causes $\dfrac{d\Phi_B}{dt} > 0$.
- Faraday's law: $\mathcal{E} = -\dfrac{d\Phi_B}{dt}$.
- Induced EMF is in negative direction, $\mathcal{E} < 0$,
  which is counterclockwise.
- Induced EMF reflects induced electric field:
  $\mathcal{E} = \oint_C \vec{E} \cdot d\vec{\ell}$.
- Field lines of induced electric field are closed.
- Faraday's law is a dynamics relation between electric and magnetic fields: $\oint_C \vec{E} \cdot d\vec{\ell} = -\dfrac{d}{dt} \int_S \vec{B} \cdot d\vec{A}$.