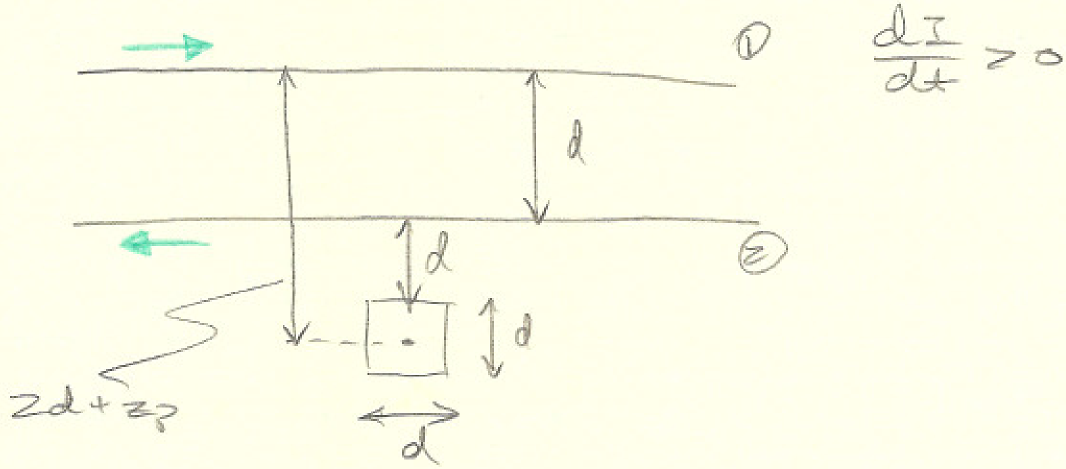
Induction

Varying $\int \vec{B} \cdot d\vec{s}$ leads to V_{EMF}.

Ex: transformer EMF (V_{EMF}^{tr})



Find the EMF.

$$\oint \vec{H} \cdot d\vec{l} = I_{enclosed} = |\vec{H}| \cdot 2\pi(2d+z_p)$$

$$|\vec{H}| = \frac{I}{2\pi(2d+z_p)}$$

$$\vec{B}_1 = \frac{\mu_0 I}{2\pi(2d+z_p)} \qquad \vec{B}_2 = \frac{\mu_0 I}{2\pi(d+z_p)}$$

$$\Phi_m = \Phi_{w1} + \Phi_{w2}$$

$$\Phi_{w1} = \int_0^d dx \int_0^d dy \, (-1) \frac{\mu_0 I}{2\pi(2d+z_p)}$$

$$= -\frac{d\mu_0 I}{2\pi} \ln(2d+z_p)\Big|_0^d$$

$$= -\frac{d\mu_0 I}{2\pi} \ln\left[\frac{3d}{2d}\right]$$

$$\hat{out} \cdot \hat{out} = +1$$

$$\Phi_{wz} = \int_0^d dx \int_0^d dz \, \frac{\mu_0 I}{2\pi(d+z)}$$

$$= \frac{d\mu_0 I}{2\pi} \ln 2$$

$$\Phi_{net} = \frac{\mu_0 d I}{2\pi}\left(\ln 2 - \ln 3/2\right)$$

$$= \frac{\mu_0 d I}{2\pi}\left(\ln\left(\frac{4}{3}\right)\right)$$

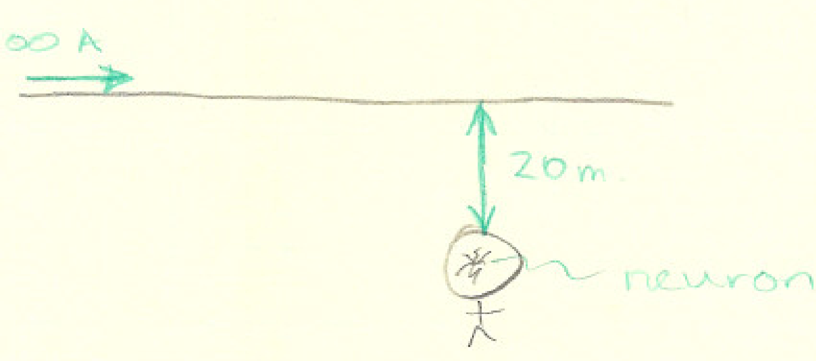
$$\frac{d\Phi}{dt} = \frac{\mu_0 d}{2\pi} \ln\left(\frac{4}{3}\right) \frac{dI}{dt} > 0$$

since $\frac{dI}{dt} > 0$

$V_{EMF} = -\frac{d\Phi}{dt}$ $\therefore$ reverse direction

$$|V_{EMF}| = \frac{\mu_0 d}{2\pi} \ln\left(\frac{4}{3}\right)\left|\frac{dI}{dt}\right|$$

EX: High voltage line, 100 A $\quad \omega = 2\pi 60$



For simply, $\vec{B}$ is constant across the cell

B of the wire at 20 m

$$|\vec{B}| = \frac{\mu_0 I}{2\pi d} = \frac{4\pi 10^{-7} \cdot 100}{2\pi\,(20\,m)} = 10^{-6}\ T$$

$$\Phi_m = B \cdot \text{Area}$$

$$d\Phi_m \cong \omega B \cdot \text{Area}$$

$$= 2\pi 60 \times 10^{-6} \times (50 \times 10^{-6})^2$$

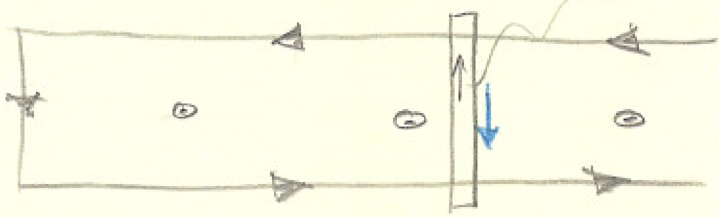
$$= 10^{-6}\ V$$

typical neural impulse $\sim 10^{-1}\ V$

Motional EMF (V^m_{EMF})

Moving Conductors plunged in a $\vec{B}$-field.

$$\vec{F}_m = q(\vec{u} \times \vec{B})$$



if current goes down, then electrons go up.

$q = -e$ $\quad\quad q(\vec{u} \times \vec{B})$ ....