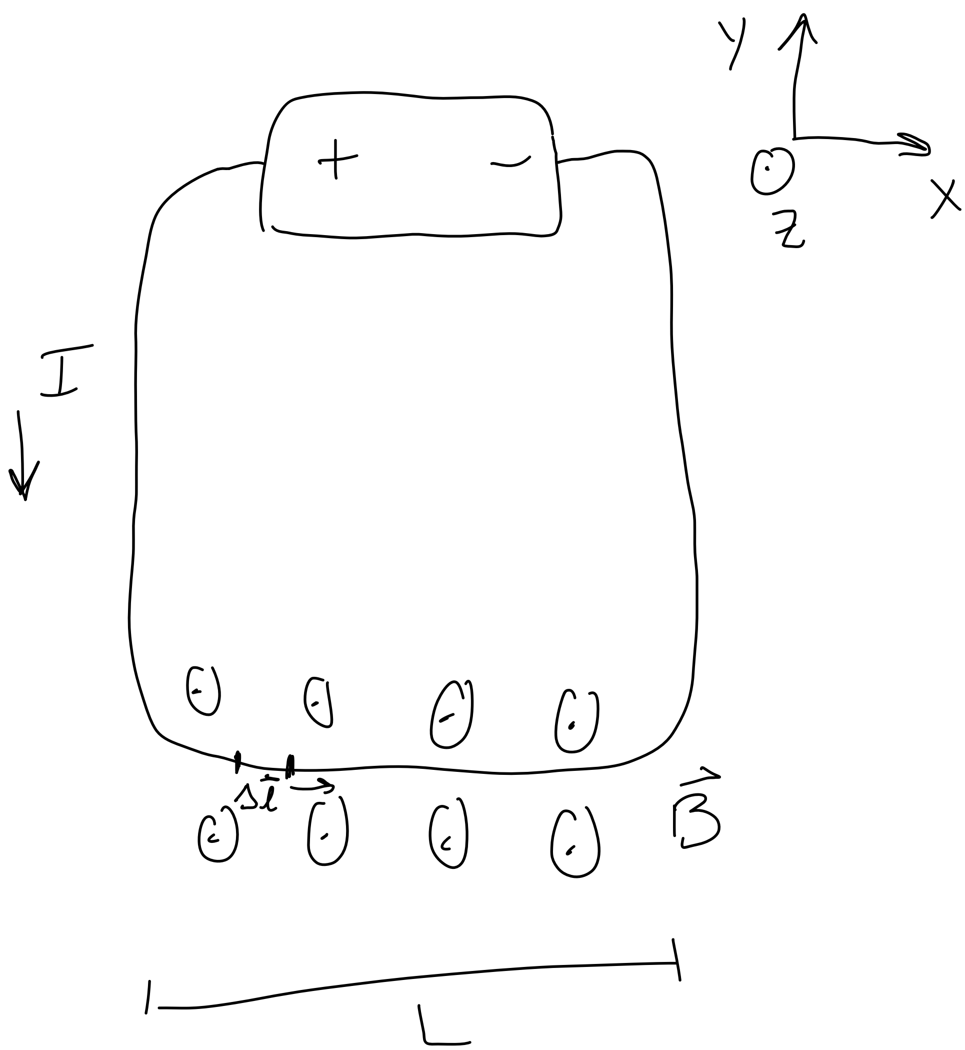
Force on a small piece of wire

$$\Delta\vec{F} = I\,\Delta\vec{l} \times \vec{B}$$

Not a "new" force



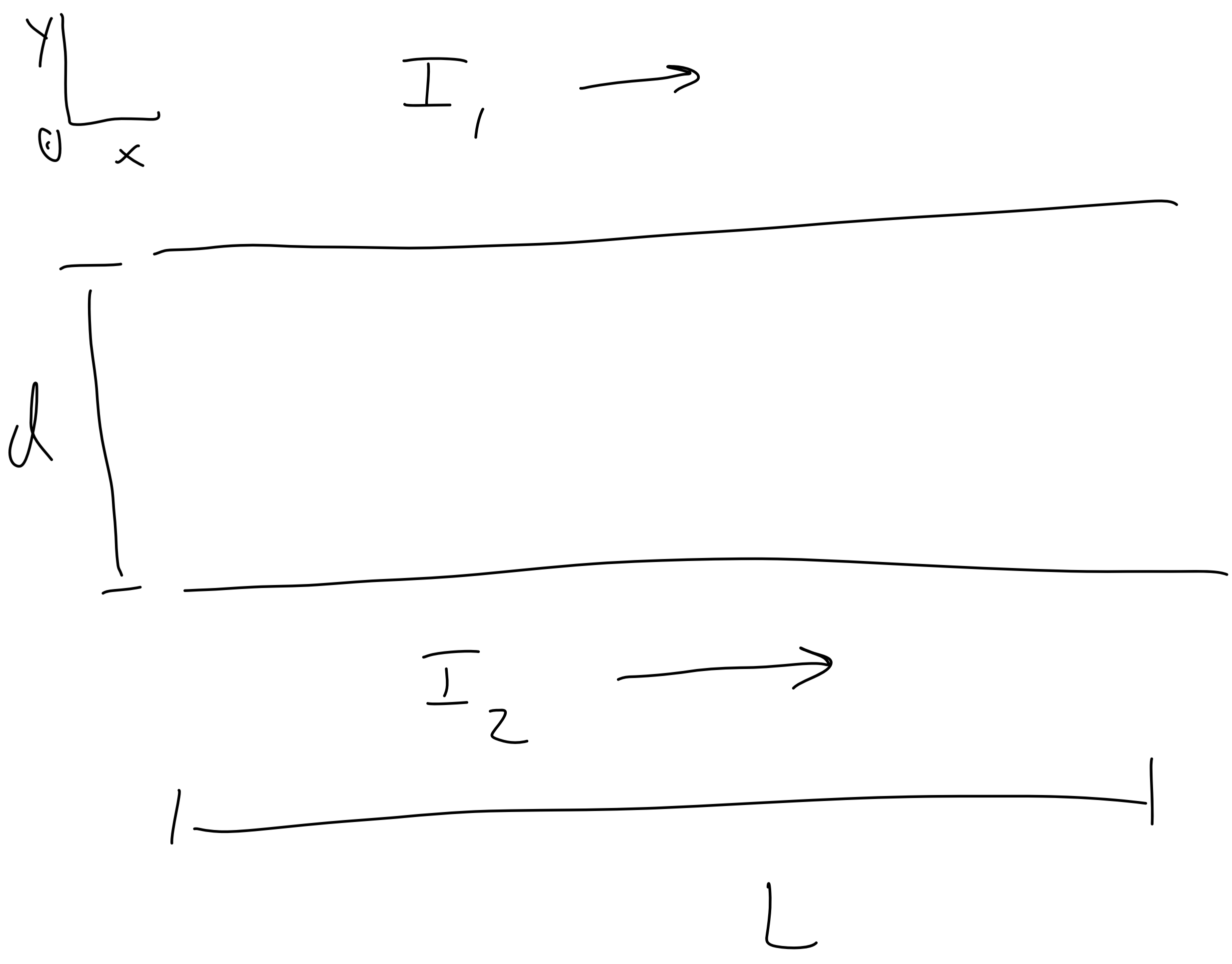
$$\Delta \vec{F} = I \Delta \vec{\ell} \times \vec{B}$$

$$= -I \Delta \ell B \hat{z}$$

$$\vec{F} = \sum -I \Delta \ell B \hat{z}$$

$$\vec{F} = -I L B \hat{z}$$

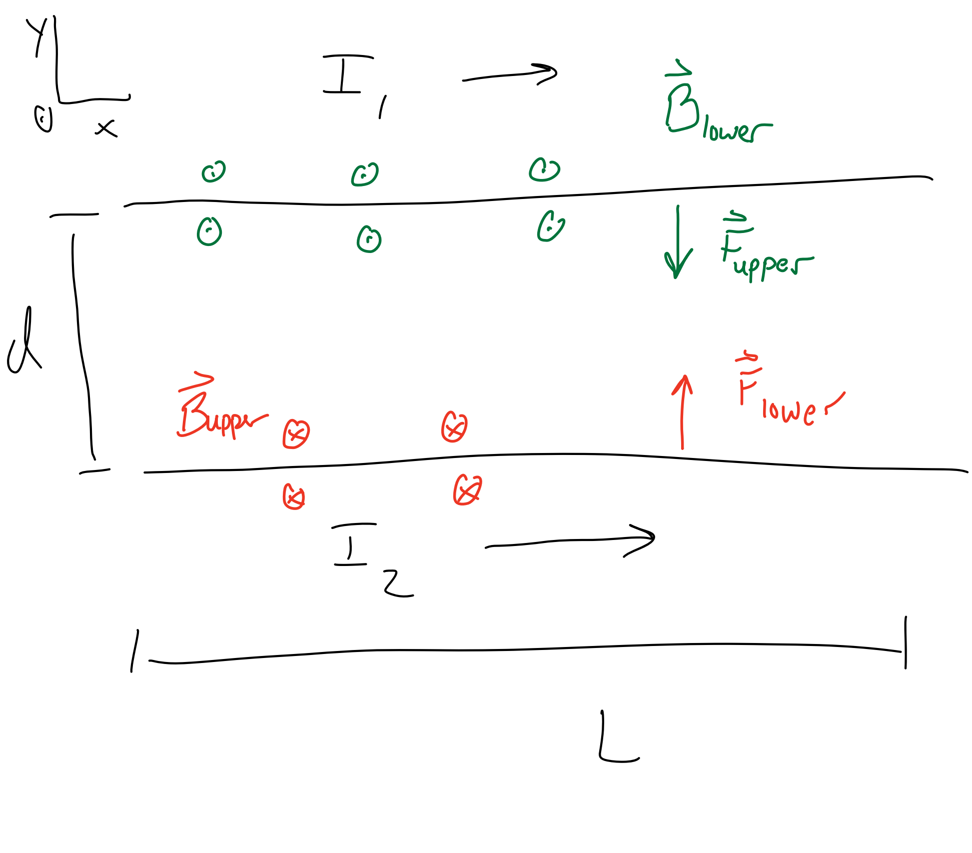
Ex: Two parallel wires



What happens?

- Each wire creates a magnetic field
- Mag field of lower wire exerts force on current of upper wire

vice-versa



1) $\vec{F}_{upper} = I_1 \Delta \vec{l} \times \vec{B}_{lower}$

Assume $d << L$

$$|\vec{B}| = \frac{\mu_0}{4\pi} \frac{2I}{r}$$

$$|\vec{B}_{lower}| = \frac{\mu_0}{4\pi} \frac{2I_2}{d}$$

$$\vec{B}_{lower} = \frac{\mu_0}{4\pi} \frac{2I_2}{d} \hat{z}$$

$$\vec{F}_{upper} = I_1 \Delta \vec{l} \times \vec{B}_{lower}$$

$$\Delta l = L\hat{x}$$

$$\vec{F}_{upper} = I_1 L\hat{x} \times \frac{\mu_0}{4\pi} \frac{2I_2}{d} \hat{z}$$

$$\vec{F}_{upper} = -2\frac{\mu_0}{4\pi} L\frac{I_1 I_2}{d} \hat{y}$$

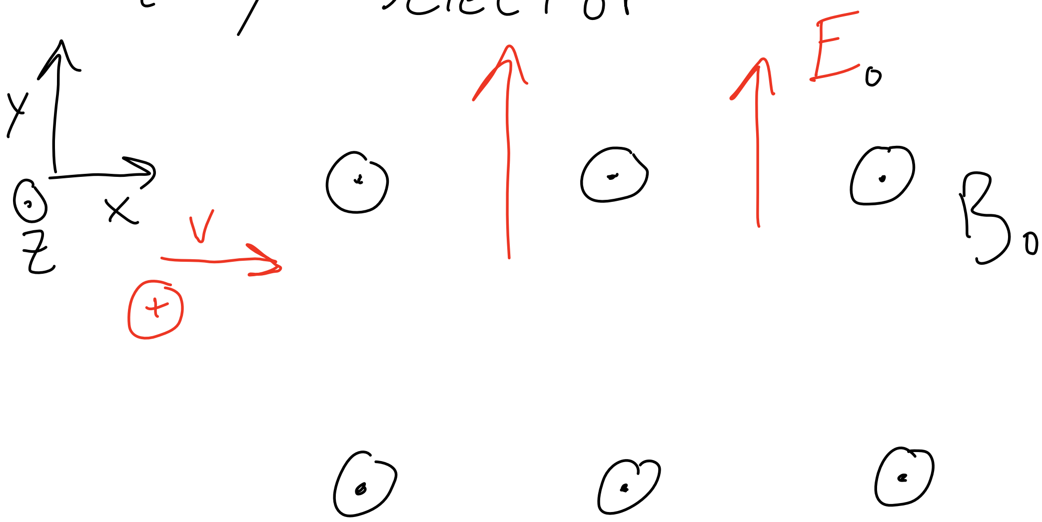
2) $\vec{F}_{lower} = I_2 \Delta\vec{l} \times \vec{B}_{upper}$

$$\vec{B}_{upper} = -\frac{\mu_0}{4\pi} \frac{2 I_1}{d} \hat{z}$$

$$\vec{F}_{lower} = I_2 L \hat{x} \times \left(-\frac{\mu_0}{4\pi} \frac{2 I_1}{d} \hat{z} \right)$$

$$\vec{F}_{lower} = 2 \frac{\mu_0}{4\pi} \frac{L I_1 I_2}{d} \hat{y}$$

velocity selector



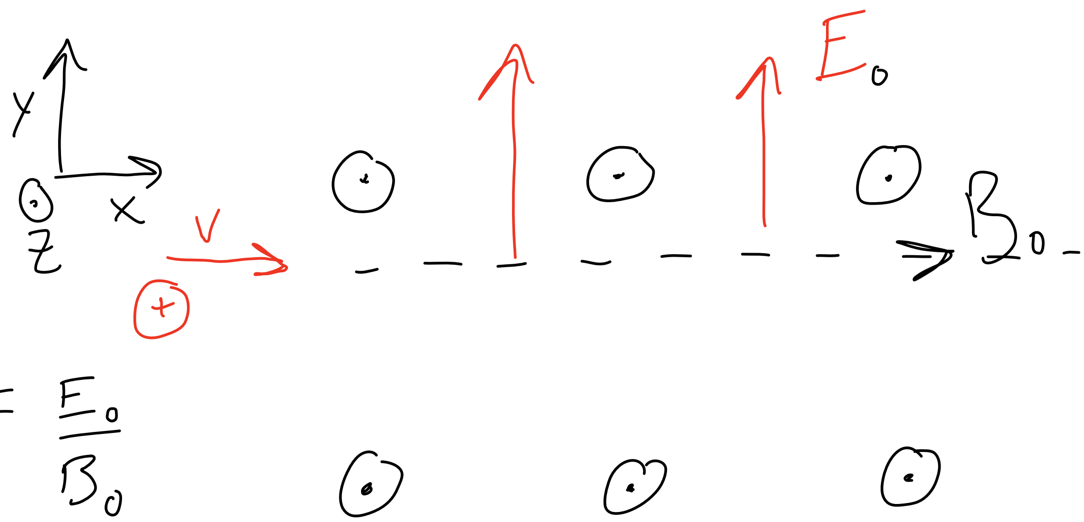
$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

$$= qE_0\hat{y} + qvB_0\,\hat{x}\times\hat{z}$$

$$-vB_0\hat{y}$$

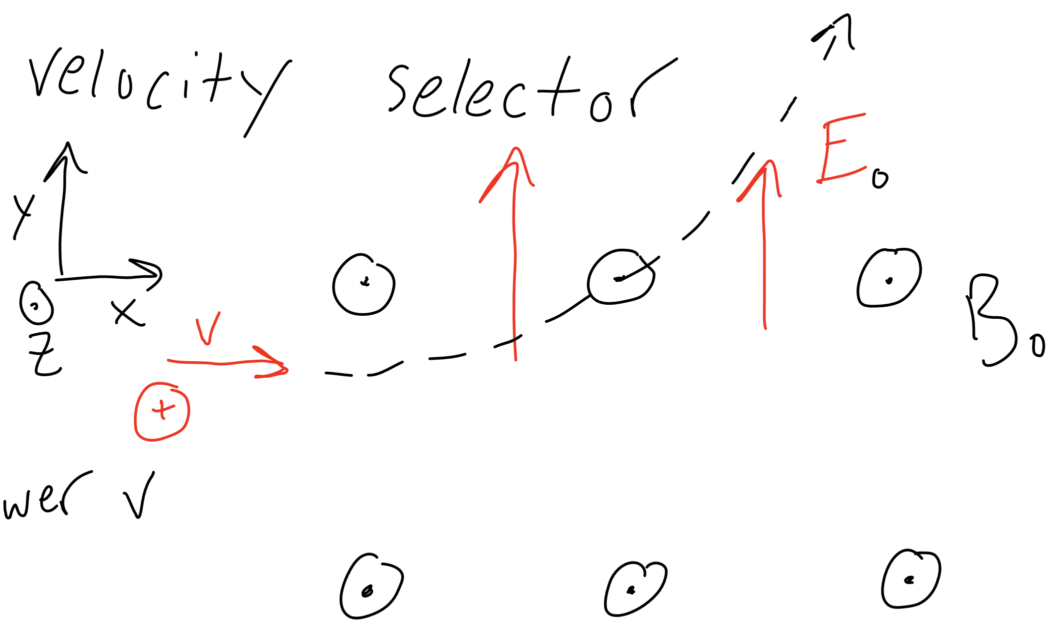
$$\vec{F} = (qE_0 - qvB_0)\,\hat{y}$$

$F = 0$ iff $E_0 = vB_0$



$v = \frac{E_0}{B_0}$

velocity selector



slower v

$$\vec{F} = (qE_0 - qvB_0)\,\hat{y}$$

$$qE > qvB$$

What about neg charges?

Yes : q cancels out

$\boxed{\text{Velocity selector}}$