Solenoids

Infinite Solenoid

coil density

$$\vec{B} = \mu_0 I n$$

\# of loops

$$= \mu_0 I \frac{N}{L}$$

given length

inside

points along axis

$$\vec{B} = 0 \text{ outside}$$

Good approximation at center of a long solenoid

If solenoid is wrapped around a ferromagnet with permeability μ

then $B = \mu I n$ inside

Iron $\mu \cong 5000\,\mu_0$

e.g. $N = 11$ coils in 1 cm

$$n = 11/\text{cm} \times \frac{100\text{ cm}}{\text{m}} = 1100/\text{m}$$

$I = 0.3\text{A}$

$$B = (4\pi \times 10^{-7})(0.3)(1100)$$

$$= 0.4\text{ mT}$$

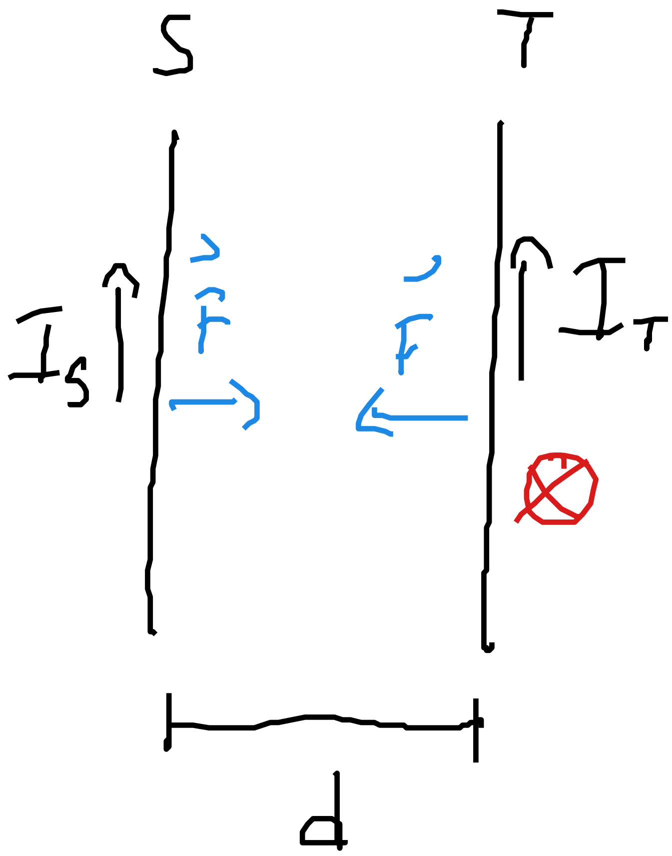
Compare Earth: $50\,\mu\text{T}$

With an iron core

$$B = 5000 \times 0.4\,mT$$

$$= 2T$$

Two wires parallel to each other



- S creates a magnetic field at T

$$\vec{B} = \frac{\mu_0 I}{2\pi d} \otimes$$

- T feels a force based on $\vec{B}$

$$\vec{F} = I\vec{L} \times \vec{B} = I_t L \frac{\mu_0 I_s}{2\pi d} \leftarrow$$

$$|\vec{F}| = \frac{\mu_0 I_s I_t}{2\pi d} L$$

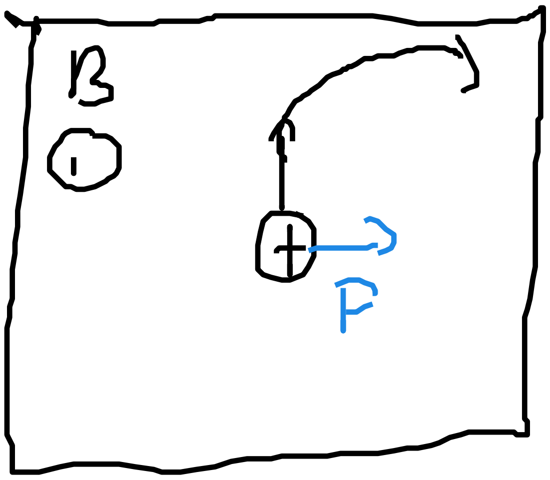
$$\frac{|F|}{L} = \frac{\mu_0 I_s I_t}{2\pi d}$$

force per length

this formula is used to define the ampere.

which is why μ_0 is exactly $4\pi \times 10^{-7}$

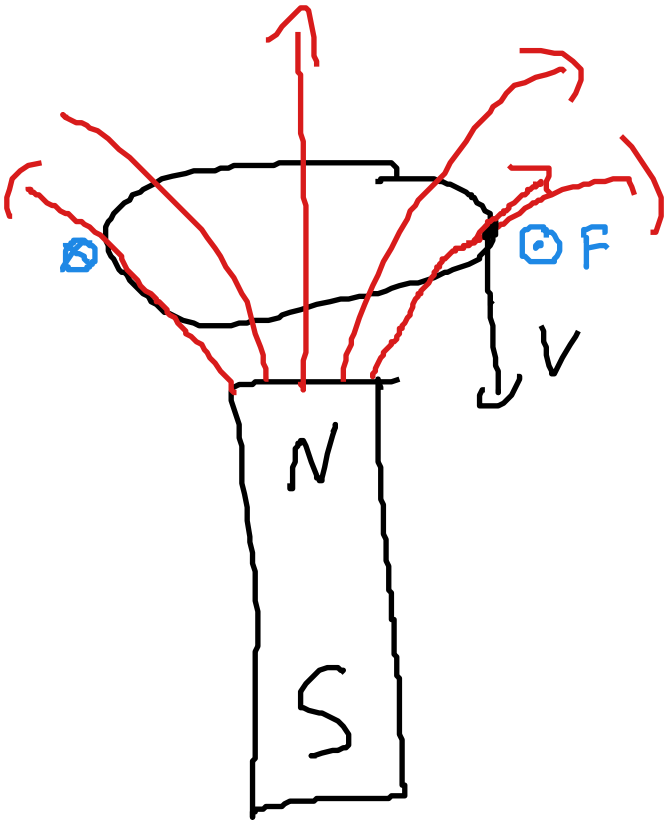
Going back for a moment



$$\vec{F} = q\vec{v} \times \vec{B}$$

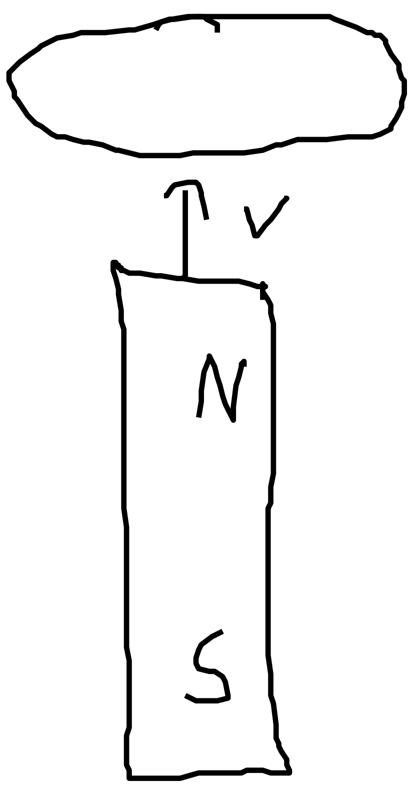
Clockwise motion

do not use circle-line RHR here!



$$\vec{F} = q\vec{v} \times \vec{B}$$

The charge carriers are pushed around the loop, creating an <u>induced</u> current.



Does a current flow or not?

Galilean invariance: this is same picture so yes

$F = qv \times B$: loop isn't moving so no