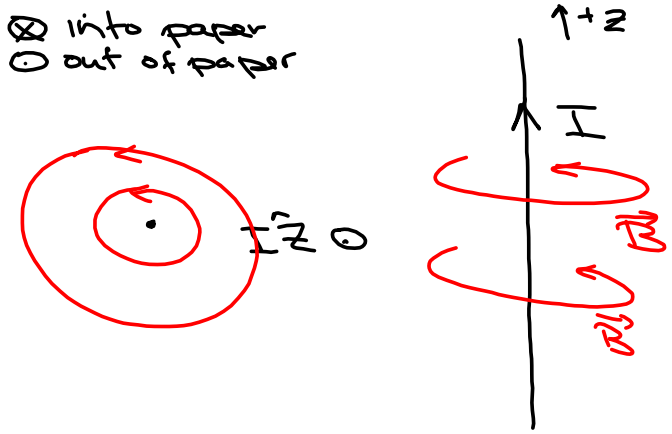
Currents and Magnetism

Oersted - 1820 - Relationship between current and magnetism

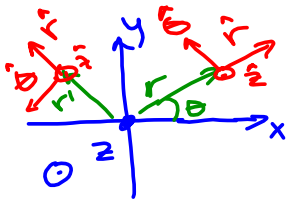
Magnetic field from long wire

$\ell \gg r$

⊗ into paper
⊙ out of paper



Cylindrical coordinate



$\hat{r} = \hat{r}(\theta)$
$\hat{\theta} = \hat{\theta}(\theta)$

If $\vec{I} = I\hat{z}$

$\vec{B} = B\hat{\theta}$

$B = \dfrac{\mu_0 I}{2\pi r}$

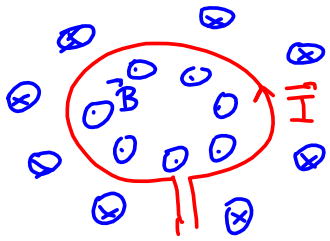
$\hat{r}$ = radially outward
$\hat{\theta}$ = CCW

permeability of free space
$\mu_0 = 4\pi \times 10^{-7}$ T/A·m

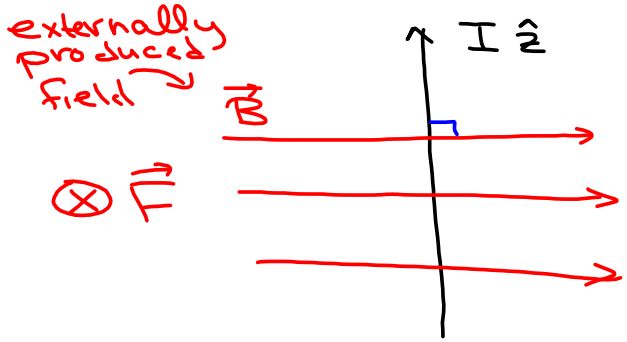
R.H. Rule.

Thumb in direction of $\vec{I}$
Fingers wrap in direction of $\vec{B}$.

Magnetic field from loop (or solenoid)



Force on a current carrying wire



wire length ℓ in field

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

$$F = \ell I B \sin\theta$$

θ: angle between $\vec{I}$ and $\vec{B}$.

R. H. Rule

Fingers in direction of I

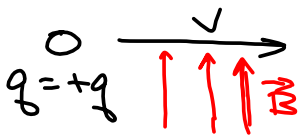
Wrap into B

Thumb points in direction of F

Equivalent: Thumb in direction of $\vec{I}$

Fingers in direction of $\vec{B}$

Palm faces direction of $\vec{F}$



$\odot \vec{F}$

$F = l I B \sin\theta$ (1)

$= l \frac{q}{t} B$

$= \frac{l}{t} q B$

$F = qvB$

$F = qvB \sin\theta$.

Examples