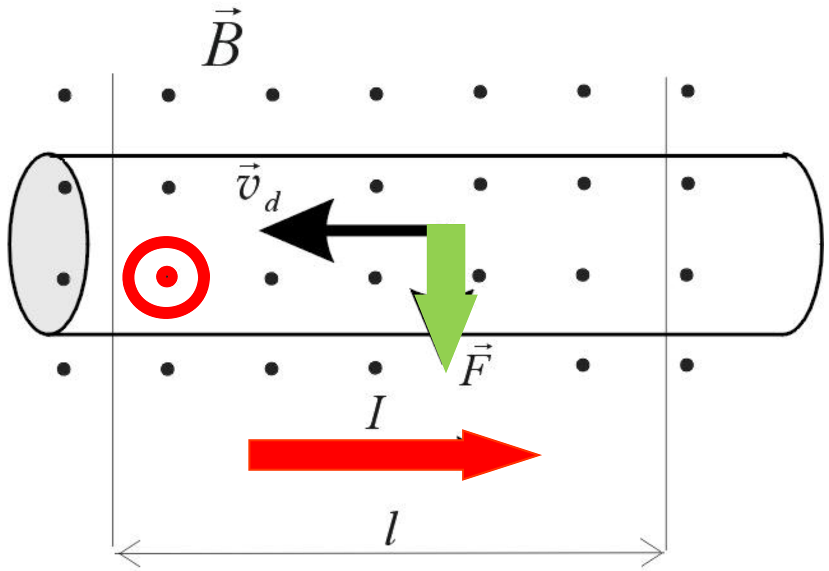
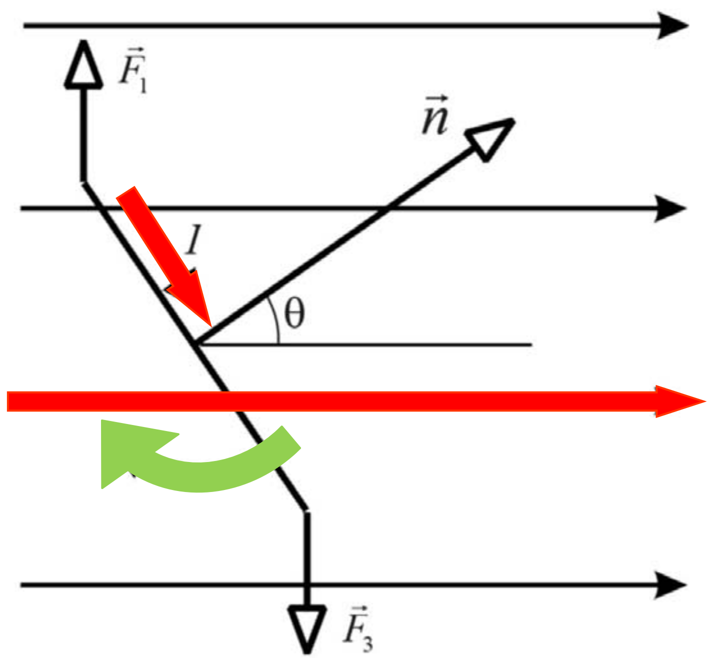
Force on a current-carrying wire

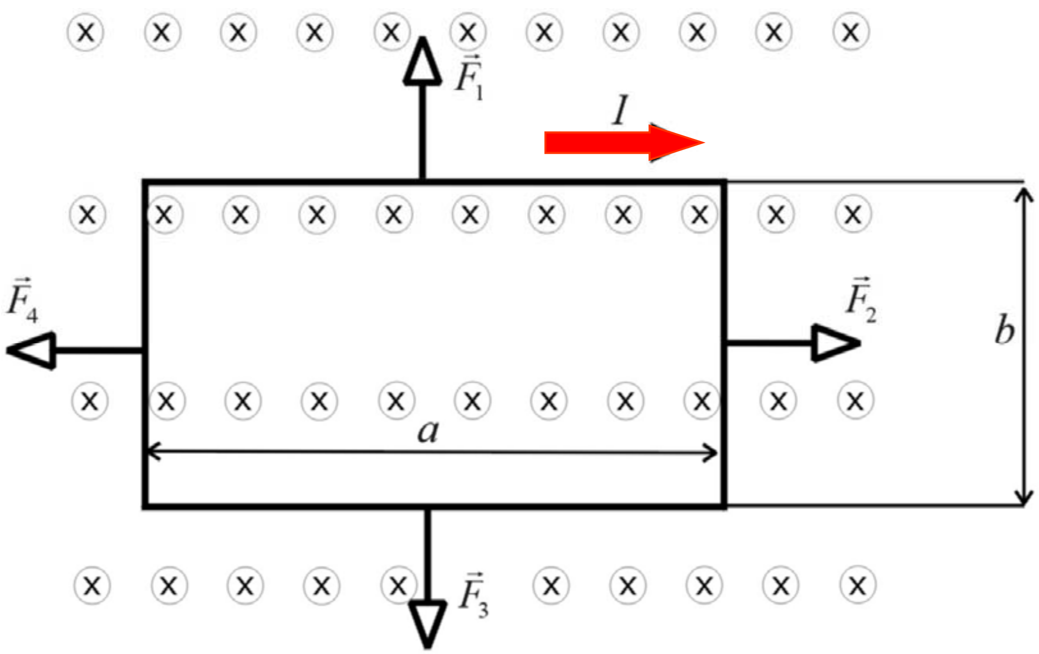


$$\vec{F} = I\vec{l} \times \vec{B}$$

$$F = IlB\sin\varphi$$

Torque on a current loop





$$M = bF_1 \sin\theta$$

$$F_1 = IaB, \ (\sin\varphi = 1)$$

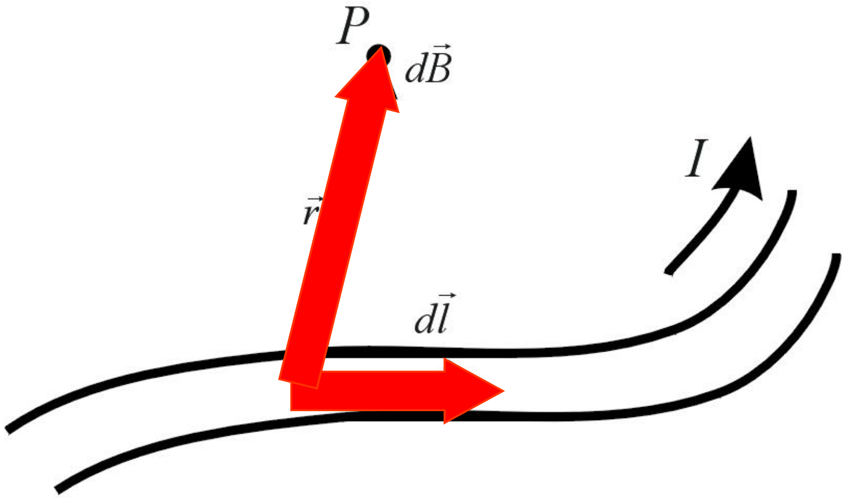
$$M = IabB\sin\theta$$

$$\vec{M} = I\vec{S} \times \vec{B}$$

$\vec{M} = NI\vec{S} \times \vec{B}$ A torque acting on a current coil of N loops

$\vec{m} = I\vec{S}$ magnetic dipole moment

Magnetic field due to current: Biot-Savart law

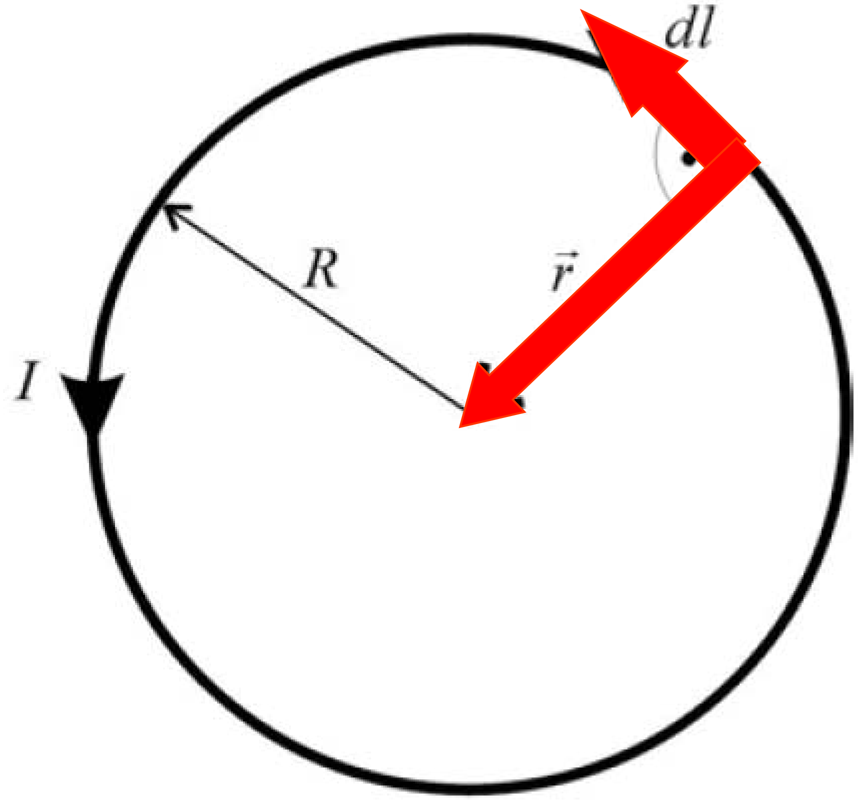


$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\left(d\vec{l} \times \vec{r}\right)}{r^3}$$

$\mu_0 = 4\pi.10^{-7}$ T.m.A^{-1} permeability constant

Magnetic field due to the circular current loop

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\left(d\vec{l} \times \vec{r}\right)}{r^3}$$



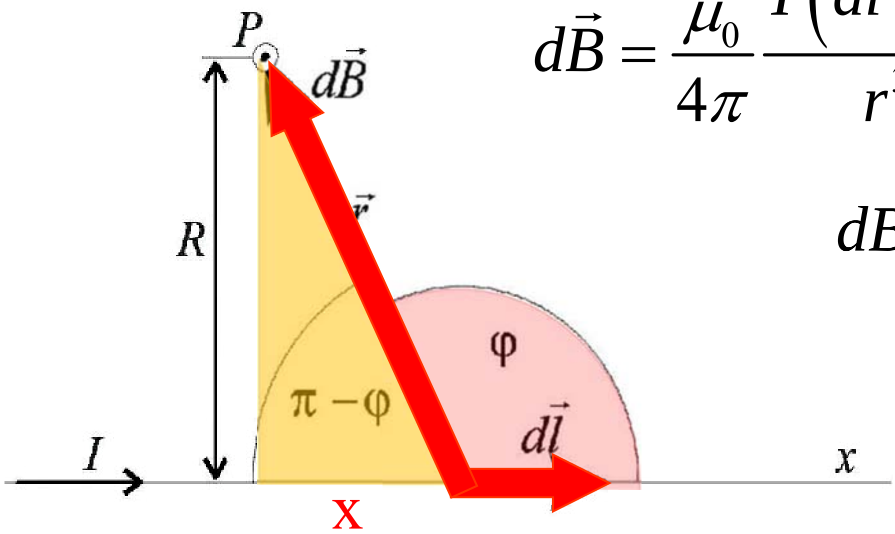
$$dB = \frac{\mu_0 I}{4\pi} \frac{dl\, r}{r^3} = \frac{\mu_0 I}{4\pi} \frac{dl}{r^2} = \frac{\mu_0 I}{4\pi} \frac{dl}{R^2}$$

$$B = \int_0^{2\pi R} \frac{\mu_0 I}{4\pi} \frac{dl}{R^2} = \frac{\mu_0 I}{4\pi} \frac{1}{R^2} \int_0^{2\pi R} dl$$

$$B = \frac{\mu_0 I}{4\pi} \frac{1}{R^2} 2\pi R = \frac{\mu_0 I}{2R}$$

$$B = \frac{\mu_0 I}{2R}$$

Magnetic field due to a current in a long straight wire



$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\left(d\vec{l} \times \vec{r}\right)}{r^3}$$

$$\vec{B} = \int d\vec{B} \qquad B = \int dB$$

$$dB = \frac{\mu_0}{4\pi} \frac{I\,dl\,r\sin\varphi}{r^3} = \frac{\mu_0}{4\pi} \frac{I\,dl\sin\varphi}{r^2}$$

$$dl = dx$$

$$r^2 = x^2 + R^2$$

$$dB = \frac{\mu_0}{4\pi} \frac{I\,dx\sin\varphi}{x^2 + R^2}$$

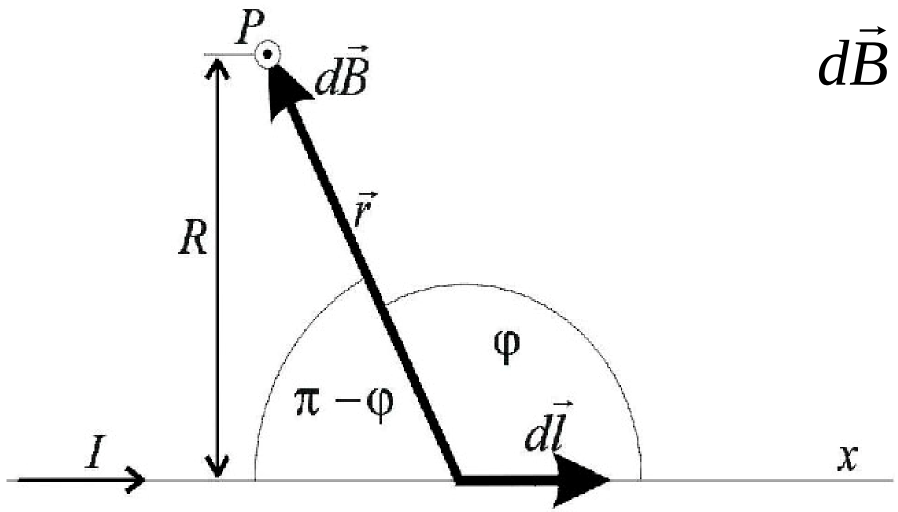
$$\sin\varphi = \sin(\pi - \varphi) = \frac{R}{\left(x^2 + R^2\right)^{\frac{1}{2}}}$$

$$dB = \frac{\mu_0}{4\pi} \frac{I\,R\,d\varphi\sin\varphi}{\sin^2\varphi\left(x^2 + R^2\right)}$$

$$\operatorname{cotg}(\varphi) = -\operatorname{cotg}(\pi - \varphi) = -\frac{x}{R}$$

$$dB = \frac{\mu_0}{4\pi} \frac{I\,d\varphi\sin\varphi}{R}$$

$$-\frac{d\varphi}{\sin^2\varphi} = -\frac{dx}{R}$$



$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\left(d\vec{l} \times \vec{r}\right)}{r^3}$$

$$B = \int_0^{\pi} \frac{\mu_0}{4\pi}\frac{I\ \sin\varphi}{R}d\varphi \ = \frac{\mu_0 I}{4\pi R}\left[-\cos\varphi\right]_0^{\pi} = \frac{\mu_0 I}{2\pi R}$$

$$B = \frac{\mu_0 I}{2\pi R}$$

Magnetic field due to the circular current loop

$$B = \frac{\mu_0 I}{2R}$$

Magnetic filed due to a current in a long straight wire

$$B = \frac{\mu_0 I}{2\pi R}$$

Force between two parallel currents

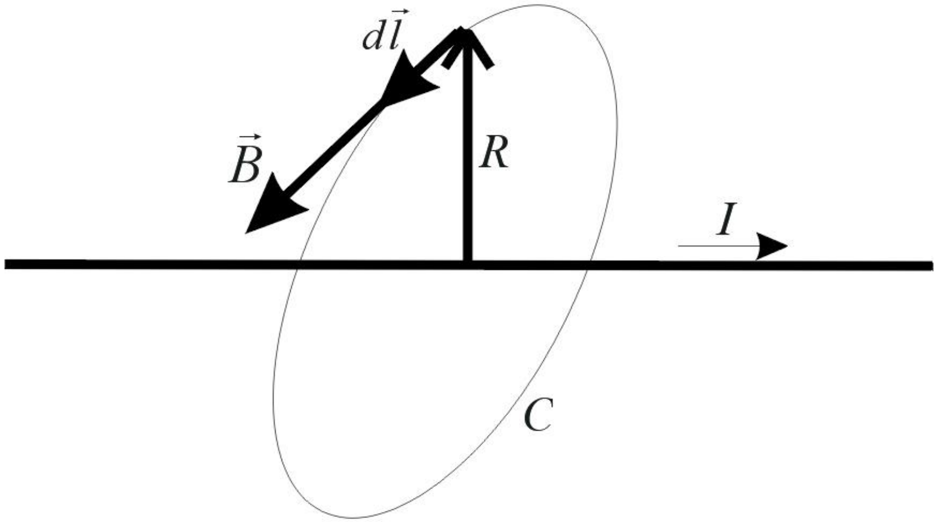
$$F = B_1 I_2 l = \frac{\mu_0 I_1 I_2}{2\pi R} l$$

The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, and placed one metre apart in vacuum, would produce between these conductors a force equal to $2 \cdot 10^{-7}$ N per metre of length.

Ampère's law

$$\oint \vec{E} \cdot d\vec{l} = 0$$

$$\oint \vec{B} \cdot d\vec{l} \neq 0$$

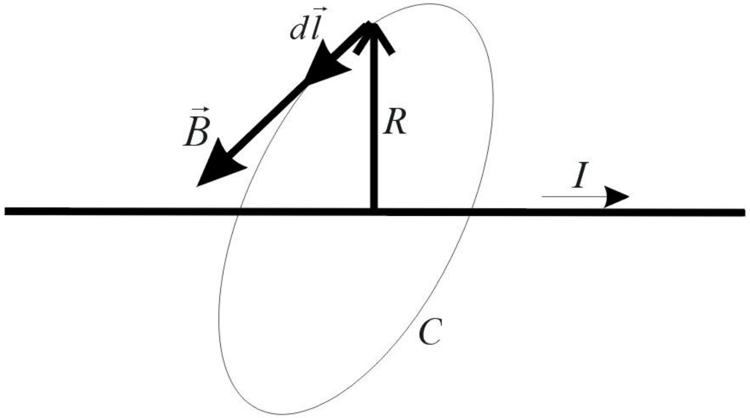


$$\oint \vec{B} \cdot d\vec{l} = \oint Bdl = B \oint dl = B2\pi R = \frac{\mu_0 I}{2\pi R} 2\pi R = \mu_0 I$$

$$B = \frac{\mu_0 I}{2\pi R}$$

$$\oint_C \vec{B} \cdot d\vec{l} = \mu_0 \sum_i I_i$$

Ampère’s law

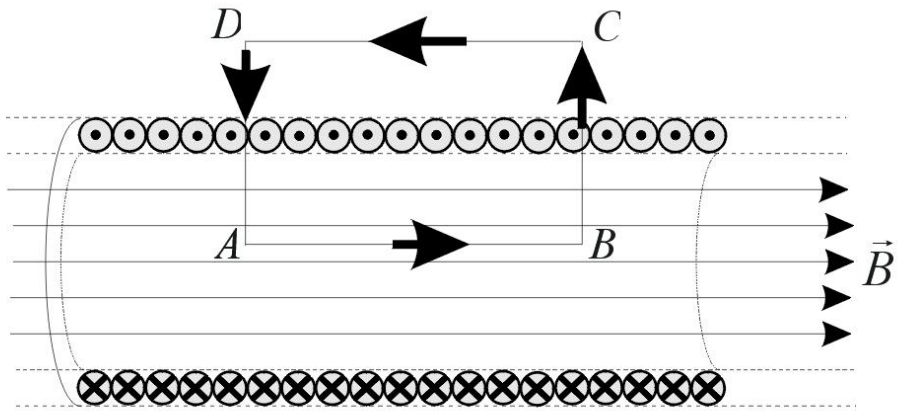

$d\vec{l}$
$\vec{B}$
R
I
C


BEHA·AMPROBE
ALC-110-EUR
LEAKAGE CLAMP
Data HOLD
Max HOLD
>2s
LIMIT
Unlock
Range
Filter
>2s
TRMS
Auto Backlight

Magnetic field of an ideal solenoid

$$\oint_{ABCD} \vec{B} \cdot d\vec{l} = \int_{AB} \vec{B} \cdot d\vec{l} + \int_{BC} \vec{B} \cdot d\vec{l} + \int_{CD} \vec{B} \cdot d\vec{l} + \int_{DA} \vec{B} \cdot d\vec{l}$$

$$\vec{B} \perp d\vec{l} \Rightarrow \int_{BC} \vec{B} \cdot d\vec{l} = \int_{DA} \vec{B} \cdot d\vec{l} = 0$$



$$\oint_{ABCD} \vec{B} \cdot d\vec{l} = \oint_{AB} \vec{B} \cdot d\vec{l} = \mu_0 \sum_i I_i$$

$$Bl_1 = \mu_0 N_1 I$$

$$B = \frac{\mu_0 N_1 I}{l_1} = \frac{\mu_0 NI}{l}$$