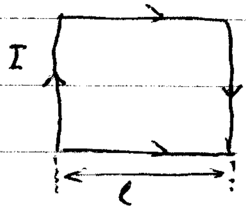
THE BIOT-SAVART LAW

A Conductor in the shape of a square of edge length $l = 0.4\,m$ carries a current $I = 10A$ (See fig). If the total length of the conductor is formed into a single circular turn with the same current, what is the value of magnetic field at the centre of the turn?

Given $I = 10A$, $l = 0.4\,m$



Since the same total length of the wire has been given circular shape, therefore in circular form the circumference must equal

$$\therefore\ 4l = 2\pi R \quad \therefore\ 2\pi R = 4 \times 0.4 = 1.6$$

$$\therefore\ R = \frac{1.6}{2\pi} = 0.255\ m$$

~~From Biot-Savart~~

the field at the centre of the loop is

$$B = \frac{\mu_0 I}{2R} = \frac{4\pi \times 10^{-7} \times 10}{2 \times 0.255}$$

$\mu_0 = 4\pi \times 10^{-7} = 1.26 \times 10^{-6}$ (permeability of free space)

$$B = \frac{4\pi \times 10^{-7} \times 10}{2 \times 0.255} = \boxed{24.7 \times 10^{-6}\ T}$$

AMPERE'S LAW AND THE MAGNETIC FIELD OF SOLENOIDE.

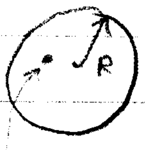
A cylindrical conductor of $R = 2.5\,cm$ carries a current $I = 2.5\,A$ along its length; this current is uniformly distributed throughout the cross-section of the conductor. Calculate the magnetic field midway along the radius of the wire (that is, at $r = R/2$)

Given

$$R = 2.5\,cm = 0.025\,m$$

$$I = 2.5\,A$$

$$B = ?$$



Since in this case r is midway and is equal to $r = R/2 = 0.0125\,m$ we use eq 30.17

Midway $r = R/2$ for this case see eq 30.17

$$\therefore \quad B = \left(\frac{\mu_0 I}{2\pi R^2}\right) r \quad \text{for } r \leq R$$

$$\therefore \quad B = \frac{1.26\times10^{-6}\times2.5}{2\times3.14\times(0.025)^2}\times0.0125$$

$$= 1.0\times10^{-5} = 10\times10^{-6}\ T$$

$$B = \boxed{10\ \mu T}$$

THE MAGNETIC FIELD ALONG THE AXIS OF A SOLENOIDE. $102 \frac{30}{4}$

A Short Solenoide, with a length of 10 cm and a radius of 5 cm, consists of 200 turns of fine wire that carries a current of 15 A. What is the magnetic field strength B at the centre of the solenoide? For the same number of turns per unit length, what value of B would result for $l \to \infty$?

$l = 10\,cm = 0.1\,m$

$N = 200 \;\therefore\; n = 200/0.1 = 2000$ turns/m

$r = 5\,cm = .05\,m$

(a) $B = \mu_0 n I$ — magnetic field at the centre Eq. Page 848

$= 1.26 \times 10^{-6} \times 2000 \times 15$

$= 0.0378$

$B = 37.8\ mT$

(b) when $l \to \infty$

then

$B = \frac{1}{2} \mu_0 n I = \frac{1}{2} \times 1.26 \times 10^{-6} \times 2000 \times 15$

$B = \boxed{18.9\ mT}$

THE MAGNETIC FORCE BETWEEN TWO PARALLEL CONDUCTORS. 102 $\frac{30}{2}$

Two parallel copper rods are 1 cm apart. Lightning sends a 10,000 ampere pulse of current along each conductor. Calculate the force per unit length on one conductor. Is the force attractive or repulsive?

Given $\mu_0 = 1.26\times10^{-6}\ T.m/A$

$I_1 = I_2 = 10^4\ A$

$d = 1cm = 10^{-2}\ m$

$$\therefore \quad F/l = \frac{\mu_0 I_1 I_2}{2\pi d} \qquad \text{Eq. 30.13}$$

$$= \frac{1.26\times10^{-6}\times10^4\times10^4}{2\times3.14\times10^{-2}}$$

$$F/l = \boxed{2005\ N/m} \quad \text{Attractive}$$

Since the direction of current is same in both the conductors, therefore by definition the force between them is attractive