Answer on Question #43022 – Physics – Electric Circuits

Question.

Calculate the force per length between two wires carrying same current of 0.2 Ampere and separated by 0.5 meter.

Given:

$I_1 = I_2 = I = 0.2\ A$ is the current flowing through each wire

$r = 0.5\ m$ is the distance between two wires

Find:

$\frac{F_{1\to 2}}{l} = ?$

Solution.

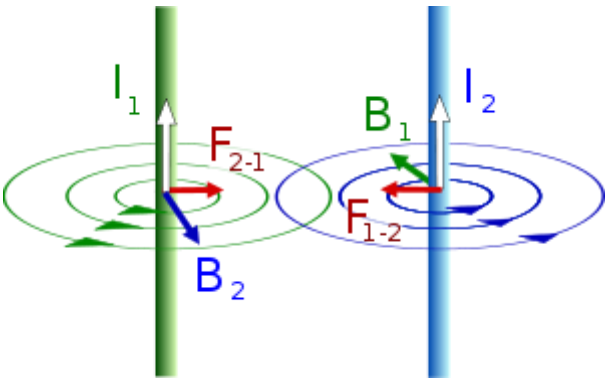

Fig.1. Our problem.

Let consider the Biot-Savart law. The Biot–Savart law is used for computing the resultant magnetic field B at position r generated by a steady current I(for example due to a wire):

$$B = \frac{\mu_0}{4\pi}\int \frac{I\vec{dl} \times \vec{r}}{r^3}$$

$\mu_0 = 4\pi \cdot 10^{-7}\ \frac{N}{A^2}$ is the magnetic constant;

$\vec{dl}$ is the length of conductor(wire), his direction is the direction of current;

$\vec{r}$ is displacement vector from the wire element to the point at which the field is being computed.

According to the Biot-Savart infinite current-carrying conductor I_1 at a point r creates a magnetic field with induction:

$$B_1 = \frac{\mu_0}{4\pi}\frac{2I_1}{r}$$

Let remember Ampère's force law:

$$dF = IBdl\sin\alpha$$

α is the angle between $\vec{B}$ and $\overrightarrow{dl}$. In our case, $\alpha = 90° \to \sin\alpha = 1$.

So, for our problem:

$$F_{1\to2} = I_2 B_1 l$$

$$\frac{F_{1\to2}}{l} = I_2 B_1 = I_2 \frac{\mu_0}{4\pi}\frac{2I_1}{r} = \frac{\mu_0}{4\pi}\frac{2I_1 I_2}{r}$$

We have, $I_1 = I_2 = I$, therefore:

$$\frac{F_{1\to2}}{l} = \frac{\mu_0}{4\pi}\frac{2I^2}{r}$$

Calculate:

$$\frac{F_{1\to2}}{l} = \frac{4\pi\cdot10^{-7}}{4\pi}\cdot\frac{2\cdot0.2^2}{0.5} = 0.16\cdot10^{-7} = 1.6\cdot10^{-8}\ \frac{N}{m}$$

Answer.

$$\frac{F_{1\to2}}{l} = \frac{\mu_0}{4\pi}\frac{2I^2}{r} = 1.6\cdot10^{-8}\ \frac{N}{m}$$