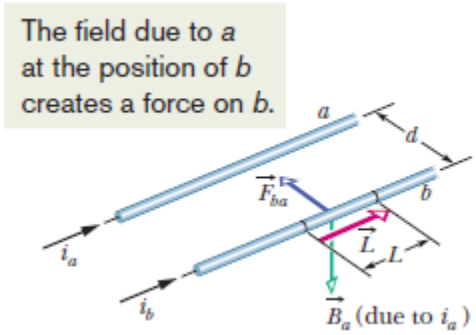
Force between two parallel current carrying conductors

Two long parallel wires carrying currents exert forces on each other. Figure shows two such wires, separated by a distance *d* and carrying currents *ia* and *ib*. Let us analyse the forces on these wires due to each other. We seek first the force on wire *b* in Fig. due to the current in wire *a*. That current produces a magnetic field and it is this magnetic field that actually causes the force we seek. To find the force, then, we need the magnitude and direction of the field *at the site of wire b*. The magnitude of at every point of wire *b* is,

$$B_a = \frac{\mu_0 i_a}{2\pi d}.$$



The curled–straight right-hand rule tells us that the direction of Ba at wire *b* is down, as figure shows. Now that we have the field, we can find the force it produces on wire *b*. Equation tells us that the force F_{ba} on a length *L* of wire *b* due to the external magnetic field is

$$\vec{F}_{ba} = i_b \vec{L} \times \vec{B}_a,$$

Where L is the length vector of the wire. In fig, vectors and are perpendicular to each other, we can write

$$F_{ba} = i_b L B_a \sin 90° = \frac{\mu_0 L i_a i_b}{2\pi d}.$$

The direction of F_{ba} is the direction of the cross product $L \times B_a$. Applying the right-hand rule for cross products to L and B_a and in Fig., we see that F_{ba} is directly toward wire *a*, as shown.

The general procedure for finding the force on a current-carrying wire is this:

To find the force on a current-carrying wire due to a second current-carrying wire, first find the field due to the second wire at the site of the first wire. Then find the force on the first wire due to that field.

We could now use this procedure to compute the force on wire *a* due to the current in wire *b*. We would find that the force is directly toward wire *b*; hence, the two wires with parallel

currents attract each other. Similarly, if the two currents were antiparallel, we could show that the two wires repel each other. Thus,

Parallel currents attract each other, and antiparallel currents repel each other.

The force acting between currents in parallel wires is the basis for the definition of the ampere, which is one of the seven SI base units. The definition, adopted in 1946, is this: The ampere is that constant current which, if maintained in two straight, parallel conductors of infinite length, of negligible circular cross section, and placed 1 m apart in vacuum, would produce on each of these conductors a force of magnitude 2×10^{-7} newton per meter of wire length.