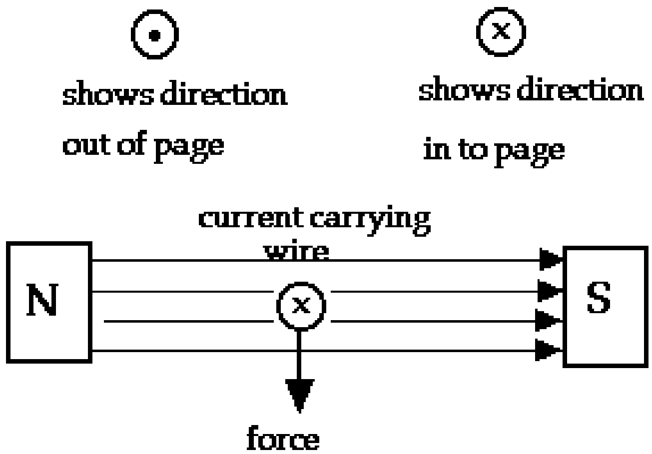
Magnetic Force on a Current Carrying Wire

When considering *conventional* current (moving positive test charges) the wire feels a force exerted in a direction that can be determined by the **RHR**.

Remember, the many fingers point in the direction of the many field lines. The thumb points in the direction of the current direction. The palm pushes in the direction of the force.
Also note that the movement of charges in a wire is measured in terms of *current* and *length* of the wire '***l***', instead of velocity and charge. Therefore, we need to find an expression relating $\mathbf{F_{mag}}$, **I**, and ***l***.

Examine the following diagram:



The magnitude of the force on each charge in the wire is given by **F = qvB**.

The force exerted on the wire must be the sum of the forces on all the charges in the wire.

In the formula **F = qvB** substitute $\mathbf{v = \frac{d}{t} = \frac{length\ of\ wire\ \ell}{t}}$

and $\mathbf{q = It}$ to get $\mathbf{F = \left(\frac{\ell}{t}\right)(It)B}$

→ cancel **t** to obtain $\mathbf{F = BI\mathit{l}}$

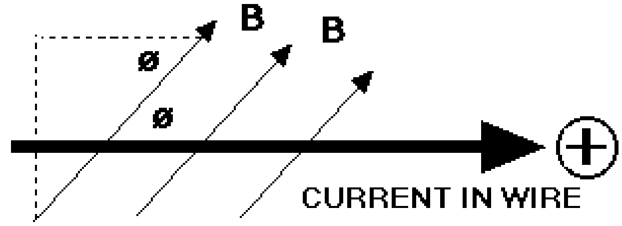
Once again, this formula was derived based on ***l*** being ⊥ to **B**. If the wire is oriented *parallel* to the magnetic field lines, <u>no</u> magnetic force will act on the wire, regardless of how much current passes through it.

Example # 8: The magnetic field strength inside a solenoid is 0.025 T. If a 3.2-cm long conducting strip positioned at right angles to the magnetic field inside the solenoid experiences a force of 5.9×10^{-4} N, what is the current in the conducting strip?

(see Electromagnetism Ex 8 for answer)

Aside: Similar to before, in college physics, you will learn that when a wire placed at an angle in the field, use the perpendicular component of the field to the wire direction so that

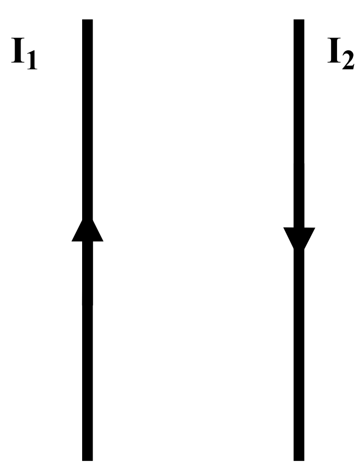
$$F = BIl \sin ø$$



Magnetic Force Between Two Long Parallel Conductors

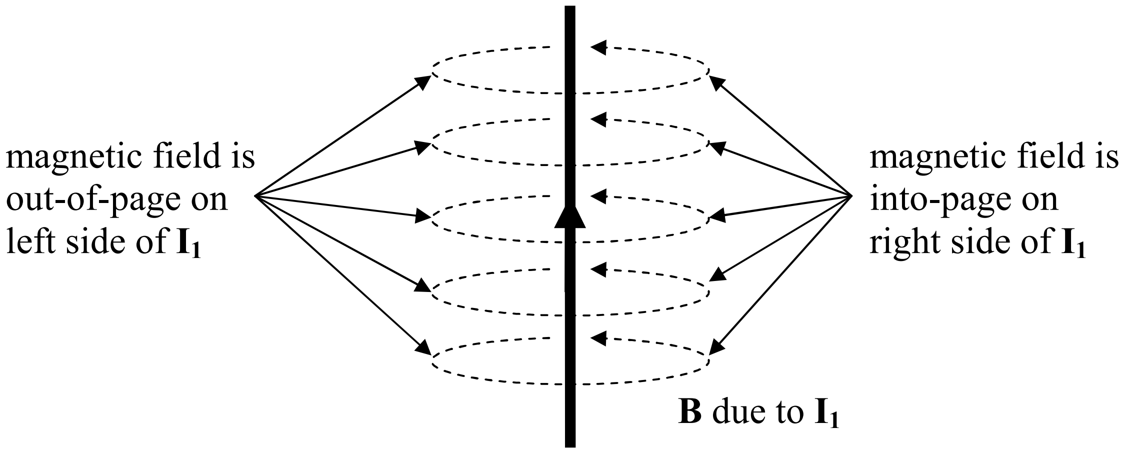
Suppose there are two parallel wires placed in close proximity to each other, each with current flowing in the *opposite* direction.

Each wire, producing its own magnetic field, exerts a magnetic force on the other. Examine the following diagram:

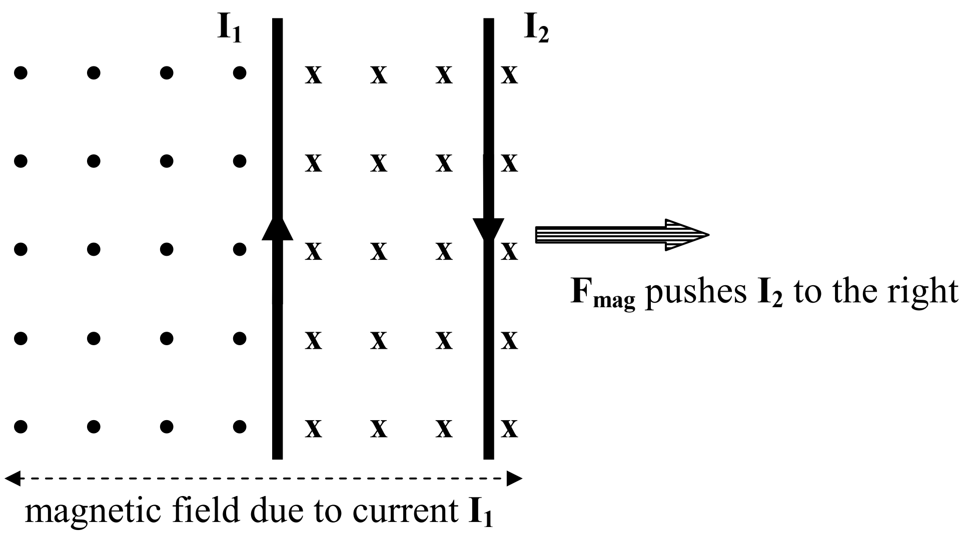


To determine the magnetic force exerted on $\mathbf{I_2}$ by $\mathbf{I_1}$:

- first determine the magnetic field **B** produced by using the **RHR** for current $\mathbf{I_1}$



- next, use the **RHR** for mag. force to determine the direction of the force acting on $\mathbf{I_2}$; draw this force direction above and describe it



Similarly, $\mathbf{I_2}$ produces a magnetic field that in turn causes a magnetic force to push $\mathbf{I_1}$ to the *left* (you can prove this yourself). In other words, two parallel wires carrying current in opposite directions *repel* each other.

Example # 9: Prove, using both types of the RHR, that two parallel wires carrying current in the *same* direction are attracted to each other.

(see Electromagnetism Ex 9 for answer)