Forces on a current-carrying wire

1

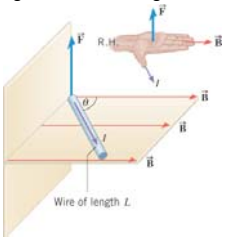
The force on a current-carrying wire

A magnetic field exerts a force $F = qvB\sin\theta$ on a single moving charge, so it's not surprising that it exerts a force on a current-carrying wire, seen as containing a set of moving charges. Using $q = I\,t$, the force is:

$$F = IvtB\sin\theta$$

In the above, the charge, q, moves through the wire in time t. So, $vt = L$, the length of the wire and

$$F = ILB\sin\theta$$



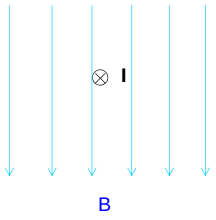
The direction of the force is given by RHR-1, where your thumb points in the direction of the current. Current is defined to be the direction of flow of positive charges, so your right hand always gives the correct direction.

2

The right-hand rule

A wire carries current into the page in a magnetic field directed down the page. In which direction is the force?

1. Left
2. Right
3. Up
4. Down
5. Into the page
6. Out of the page
7. The net force is zero



3

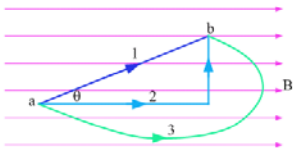
Three wires

Consider three wires carrying identical currents between two points, a and b.

The wires are exposed to a uniform magnetic field.

Wire 1 goes directly from a to b. Wire 2 consists of two straight sections, one parallel to the magnetic field and one perpendicular to the field. Wire 3 takes a meandering path from a to b. Which wire experiences more force?

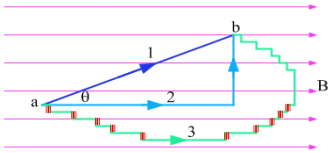
1. Wire 1
2. Wire 2
3. Wire 3
4. equal for all three



Three wires

Recall: $F = ILB\sin\theta$

The force is equal for all three. What matters is the displacement perpendicular to the field, and that's equal for all wires carrying equal currents between the same two points in a uniform magnetic field.



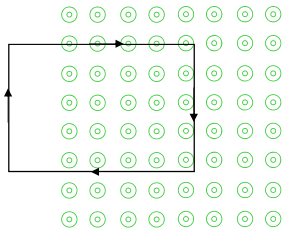
In paths 2 and 3 shown above, only the segments perpendicular to B contribute to the force. For path 3, the segments marked by ‖ sum to zero.

5

The force on a current-carrying loop I

A wire loop carries a clockwise current is partly inside a region containing a uniform magnetic field directed out of the page. In what direction is the net force on the loop?

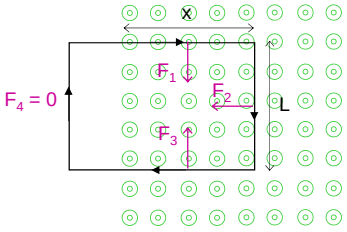
1. Left
2. Right
3. Up
4. Down
5. Into the page
6. Out of the page
7. The net force is zero
8. Not enough information to tell



6

The force on a current-carrying loop I

Each side of the loop partly or completely inside the region is subject to a magnetic force as shown below. $|F_2| = BIL$ and $|F_1| = |F_3| = BIx$, where I is the current in the loop and x is the length of the loop that is inside the region.

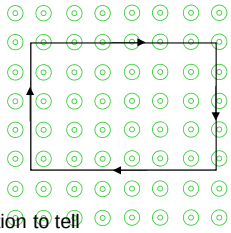


7

The force on a current-carrying loop I

A wire loop carries a clockwise current in a uniform magnetic field directed out of the page. In what direction is the net force on the loop?

1. Left
2. Right
3. Up
4. Down
5. Into the page
6. Out of the page
7. The net force is zero
8. There is not enough information to tell



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