Worksheet: Magnetic Force on a Current-Carrying Wire

(Use your right hand rules to determine direction.)

1. A wire 36 m long carries a conventional current of 22 A from west to east. Find the magnetic force on the wire if the magnetic field of Earth at this location is directed from south to north and has a magnitude of 5.0×10^{-5} T.

$l = 36m$
$I = 22A$
$B = 5.0\times10^{-5} T$
$\theta = 90°$

$F = BIl \sin\theta$
$= (5.0\times10^{-5}T)(22A)(36m)(\sin 90°)$
$= 4.356\times10^{-2}N$

$F_B = 4.4\times10^{-2}N$ up — 2 sig figs

use RHR - Thumb east - Finger to north => Force up

2. A wire 1.0 m long experiences a magnetic force of 0.50 N due to a perpendicular uniform magnetic field. If the wire carries a current of 10.0 A, what is the magnitude of the magnetic field?

$l = 1.0m$
$F_B = 0.50N$
$\theta = 90°$
$I = 10.0A$

$F = BIl\sin\theta \Rightarrow B = \frac{F}{Il\sin\theta} = \frac{0.50N}{(10.0A)(1.0m)\sin 90°}$

$= \frac{0.50N}{(10.0A)(1.0m)}$

$B = 0.050T$ — 2 sig figs

3. The magnetic force acting on a wire that is perpendicular to a 1.5 T uniform magnetic field is 4.4 N. If the current in the wire is 5.0 A, what is the length of the wire that is inside the magnetic field?

$\theta = 90°$
$B = 1.5T$
$F_B = 4.4N$
$I = 5.0A$
$l = ?$

$F = BIl\sin\theta \Rightarrow l = \frac{F}{BI\sin\theta} = \frac{4.4N}{(1.5T)(5.0A)(\sin 90°)}$

$= \frac{4.4N}{7.5\ T\cdot A}$

$= 0.5866\ m$

$l = 0.59m$ — 2 sig figs

4. A 2.5 N magnetic force acts on a 475 m wire that is perpendicular to a 0.50 T magnetic field. What is the current in the wire?

$F_B = 2.5N$
$l = 475m$
$\theta = 90°$
$B = 0.50T$
$I = ?$

$F = BIl\sin\theta \Rightarrow I = \frac{F}{Bl\sin\theta} = \frac{2.5N}{(0.50T)(475m)\sin 90°}$

$= \frac{2.5N}{237.50\ T\cdot m}$

$= 0.01053\ A$

$I = 0.01A$

5. The magnetic force on a straight 0.15 m segment of wire carrying a current of 4.5 A is 1.0 N. What is the magnitude of the component of the magnetic field that is perpendicular to the wire?

$l = 0.15m$
$I = 4.5A$
$F_B = 1.0N$
$\theta = 90°$
$B = ?$

$F = BIL\sin\theta$

$B = \frac{F}{Il\sin\theta} = \frac{1.0N}{(4.5A)(0.15m)(\sin 90°)}$

$= \frac{1.0N}{(4.5A)(0.15m)}$

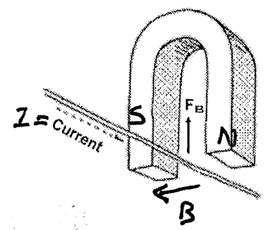
$= \frac{1.0N}{0.675\ A\cdot m}$

$= 1.481\ T$

$B = 1.5T$

6. The drawing shows a current carrying wire that passes through the gap in a horseshoe magnet. The magnetic force F_B exerts on the wire is directed upwards. Which end of the magnet is the North pole and which end is the South pole? Justify your answer.

Thumb along the wire
Finger pointed up
=> B is to the left



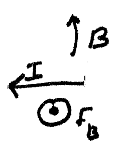
Field line originate in the north and point to the south => N on the right S on the left.

7. An electric power line carries a current of 1400 A in a location where the Earth's magnetic field is 5.0×10^{-5} T. The line makes an angle of 75° with respect to the field. Determine the magnitude of the magnetic force on a 120 m length of wire.

$I = 1400\,A$
$B = 5.0\times10^{-5}\,T$
$\theta = 75°$
$l = 120\,m$
F_B

$F_B = BIl \sin\theta$
$= (5.0\times10^{-5}\,T)(1400\,A)(120\,m)(\sin 75°)$
$= (5.0\times10^{-5}\,T)(1400\,A)(120\,m)(0.9659)$
$= 8.114\,N$
$\boxed{F = 8.1\,N}$

8. Near the equator in South America the earth's magnetic field has a strength of 3.2×10^{-5} T. The field at this location is parallel to the surface of the Earth and points due North. A straight wire, 46 m in length, has a east-west orientation and experiences a magnetic force of 0.058 N, directed vertically downward (toward the Earth). What is the magnitude and direction of the current in the wire?



$B = 3.2\times10^{-5}\,T$ [North]
$l = 46\,m$
$\theta = 90°$
$F_B = 0.058\,N$ [down]
$I = ?$

① $F_B = BIl\sin\theta$
$I = \frac{F}{Bl\sin\theta}$
$= \frac{(0.058\,N)}{(3.2\times10^{-5}\,T)(46\,m)(\sin 90°)}$
$= 39.40\,A$

② Use RHR for direction
I runs to the west

9. At New York City, the Earth's magnetic field has a vertical (downward) component of 5.2×10^{-5} T and a horizontal component of 1.8×10^{-5} T that is directed toward the geographical north. What is the magnitude of the magnetic force on a long, straight wire 6.0 m in length, that carries a 28 A current due East? (Hint: you will need to use Pythagoras' Theorum to add the two vectors together.) Note There is a vertical and horizontal componant to B at most places on earth because of the declination of the magnetic field.

$B_H = 5.2\times10^{-5}\,T$ [Down]
$B_V = 1.8\times10^{-5}\,T$ [North]
$l = 6.0\,m$
$I = 28\,A$ [east]
* $\theta = 90°$
$\vec{F}_H = ?$
$\vec{F}_V = ?$
$\vec{F}_{net} = \vec{F}_H + \vec{F}_V$

① $F_H = B_H I l$
$= (5.2\times10^{-5}\,T)(28\,A)(6.0\,m)$
$= 8.736\times10^{-3}\,N$

② $F_V = B_V I l$
$= (1.8\times10^{-5}\,T)(28\,A)(6.0\,m)$
$= 3.024\times10^{-3}\,N$

③ $\vec{F}_{Net}^2 = \vec{F}_H^2 + \vec{F}_V^2$
$= (8.736\times10^{-3})^2 + (3.024\times10^{-3})^2$
$= 7.6322\times10^{-5}\,N^2 + 9.144\times10^{-6}\,N^2$
$F_{net}^2 = 8.5461\times10^{-5}\,N^2$
$F_{net} = 9.244\times10^{-3}\,N$
$\boxed{F_{net} = 9.2\times10^{-3}\,N}$

* $\theta = 90°$ since [N] and [down] are perpendicular and [E] and [N] are perpendicular

(4) Alternative solution

Find B_{net}.

$\vec{B}_H = 5.2 \times 10^{-5} T$ [Down]

$\vec{B}_V = 1.8 \times 10^{-5} T$ [North]

$\vec{B}_{net} = ?$

$\ell = 6.0 m$

$I = 28 A$

(1)

$$B_{net}^2 = B_V^2 + B_H^2$$

$$= (1.8 \times 10^{-5} T)^2 + (5.2 \times 10^{-5} T)^2$$

$$= (3.24 \times 10^{-10} T^2) + (2 \times 10^{9} T^2)$$

$$B_{net}^2 = 3 \times 10^{-9} T^2$$

$$\boxed{B_{net} = 5.502 T}$$

(2)

$$F_{net} = B_{net} I \ell$$

$$= (5.502 T)(28 A)(6.0 m)$$

$$\boxed{F_{net} = 9.2 \times 10^{-3} N}$$