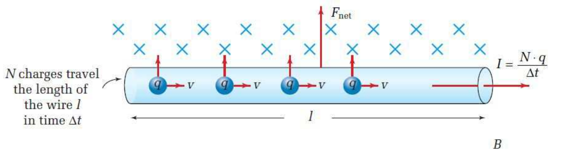
SPH4U UNIVERSITY PHYSICS

GRAVITATIONAL, ELECTRIC, & ... FIELDS

☞ Magnetic Force on a Current-Carrying … (P.392-396)

A Current-Carrying Conductor in a Magnetic Field

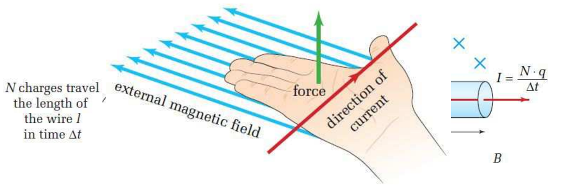
The magnetic force experienced by a charged particle moving freely through a perpendicular magnetic field can be compared to the force exerted on a current-carrying conductor that also is perpendicular to the magnetic field. In this case, the net force on a conductor of length L will be the total of the individual forces acting on each charge.



November 25, 2012 — 4U3 - Magnetic Force on a Current-Carrying Conductor — 1

A Current-Carrying Conductor in a Magnetic Field

As before, the right-hand rule you used for a charge moving in a magnetic field can be used to determine the direction of the magnetic force on a current-carrying conductor. The only difference is that the direction of the current replaces the direction of v for a moving charge.



November 25, 2012 — 4U3 - Magnetic Force on a Current-Carrying Conductor — 2

A Current-Carrying Conductor in a Magnetic Field

MAGNETIC FORCE ON A CURRENT CARRYING CONDUCTOR (F_M)

$$F_M = ILB\sin\theta$$

where F_M is the magnetic force on a current-carrying conductor (N)
I is the current in the conductor (A) ☞ *1 A = 1 C/s*
L is the length of the conductor (m)
B is the strength of the magnetic field (T) ☞ *1 T = 1 kg/C·s*
θ is the angle between I and B

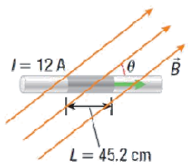
NOTE!
Current replaces the velocity of a moving charge in the right-hand rule.

A Current-Carrying Conductor in a Magnetic Field

PRACTICE

1. A piece of wire 45.2 cm long has a current of 12 A. The wire moves through a uniform magnetic field with a strength of 0.30 T. Calculate the magnitude of the magnetic force on the wire when the angle between the magnetic field and the wire is 0°, 45°, and 90°.

F_M = 0 N
F_M = 1.2 N [up]
F_M = 1.6 N [up]

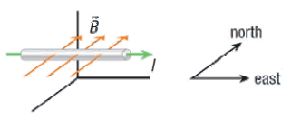


A Current-Carrying Conductor in a Magnetic Field

PRACTICE

2. Two electrical poles support a current-carrying wire. The mass of the 2.5 m segment of wire is 0.44 kg. A 15 A current travels through the wire. The conventional current is oriented due east, horizontal to Earth's surface. The strength of Earth's magnetic field at the location is 57 μT and is oriented due north, horizontal to Earth's surface.
   (a) Determine the magnitude and the direction of the magnetic force on the 2.5 m segment of wire..

(a) $F_M = 2.1 \times 10^{-3}$ N [up]

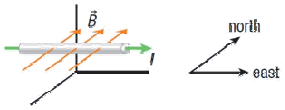


A Current-Carrying Conductor in a Magnetic Field

PRACTICE

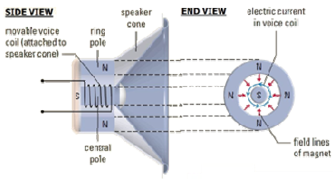
2. Two electrical poles support a current-carrying wire. The mass of the 2.5 m segment of wire is 0.44 kg. A 15 A current travels through the wire. The conventional current is oriented due east, horizontal to Earth's surface. The strength of Earth's magnetic field at the location is 57 μT and is oriented due north, horizontal to Earth's surface.
   (b) Calculate the gravitational force on the 2.5 m segment of wire.

   (b) F_g = 4.3 N [down]



Applications of … – Loudspeakers

The wire coil inside the speaker is part of an electromagnet. Electrical signals corresponding to sounds produce a changing current in the coil which produces a changing magnetic field around the coil. The permanent magnet also has a magnetic field which exerts a force on the current-carrying wire. Variations in the current produce variations in the force on the wires in the coil. The coil moves back and forth in response, causing the cone to vibrate, pushing sound waves through the air to your ears.



Applications of … – Electromagnetic Pumps

An understanding of the magnetic force on a current enabled medical researchers to devise electromagnetic pumps to move fluids in kidneys and artificial hearts. Traditional mechanical pumps can cause damage to blood cells. The use of magnetic fields eliminates this problem. Scientists are able to keep the blood flowing to the heart during kidney dialysis, for example, by creating a magnetic field over tubes of blood containing an electric current. A magnetic force acting on the charged particles keeps the blood in motion.

✔ Check Your Learning

TEXTBOOK
P.396 Q.3,4

WIKI (EGM FIELDS)
✎.... 4U3 - QUIZ#3 (Charged Particles & Fields)