Physics 25 Practice Problems Chapter 21

1. Assume the magnetic field in this room points from left to right. If an electron is fired in front of an observer from the ceiling to the floor, what will be the direction of the magnetic force on the electron?

2. If a proton is fired near the Earth, parallel to the Earth's surface, from west to east, what would be the direction along which the proton would be deflected?

3. A proton is fired toward the ground at the equator. What is the direction of the magnetic force on the proton, due to Earth's magnetic field?

4. An electron from the Sun approaches the Earth at the equator, along a direction perpendicular to the ground. In which direction will it be deflected?

5. Looking at the face of a circular loop of wire carrying current in the clockwise direction, which polarity (N or S) of the loop's equivalent bar magnet does one see?

6. What current in a circular coil of 1000 turns of radius 0.04 m will produce a magnetic field intensity B at its center equal to 4000 G?

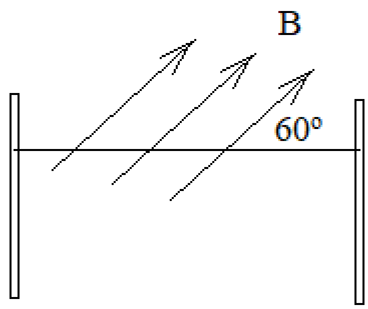
7. The current in a long straight wire is 300 A. In a direction parallel to the direction of the current, and 4.0 cm from it, an electron is fired at speed 2×10^6 m/s. What is the magnetic force on the electron due to the magnetic field of the wire?

8. A proton has a speed of 5.0×10^6 m/s. It encounters a magnetic field whose magnitude is 0.40 T and whose direction makes a 30-degree angle with respect to the proton's velocity. What is the acceleration of the proton?
(Note: proton mass = 1.67×10^{-27} kg.)

9. A beam of protons moves in a circle of radius 0.25 m; the plane of the circle is perpendicular to a 0.30 T magnetic field. What is the speed of each proton?

10. An electron has a kinetic energy of 2.0×10^{-17} J. It moves on a circular path that is perpendicular to a magnetic field of magnitude 5.3×10^{-5} T. Determine the radius of the path.

11. A 45-m length of wire is stretched horizontally above the ground between two vertical posts. The wire carries a current of 75 A, and experiences a magnetic force of 0.15 N. Find the magnitude of Earth's magnetic field at the location of the wire, assuming the field makes an angle of 60 degrees with respect to the wire.

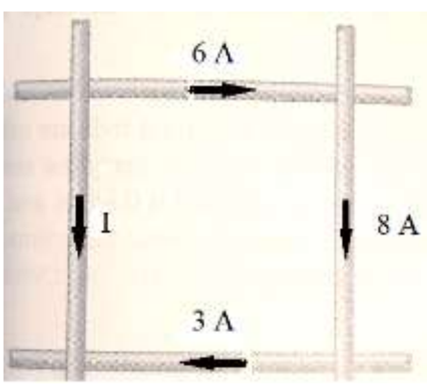


12. Two insulated wires, each 2.40 m long, are taped together to form a two-wire unit that is 2.40 m long. One wire carries a current of 7 A; the other carries a smaller current I in the opposite direction. The wire pair is placed at an angle of 65 degrees relative to a magnetic field whose magnitude is 0.360 T. The magnitude of the net magnetic force on the pair is 3.13 N. What is the current I?

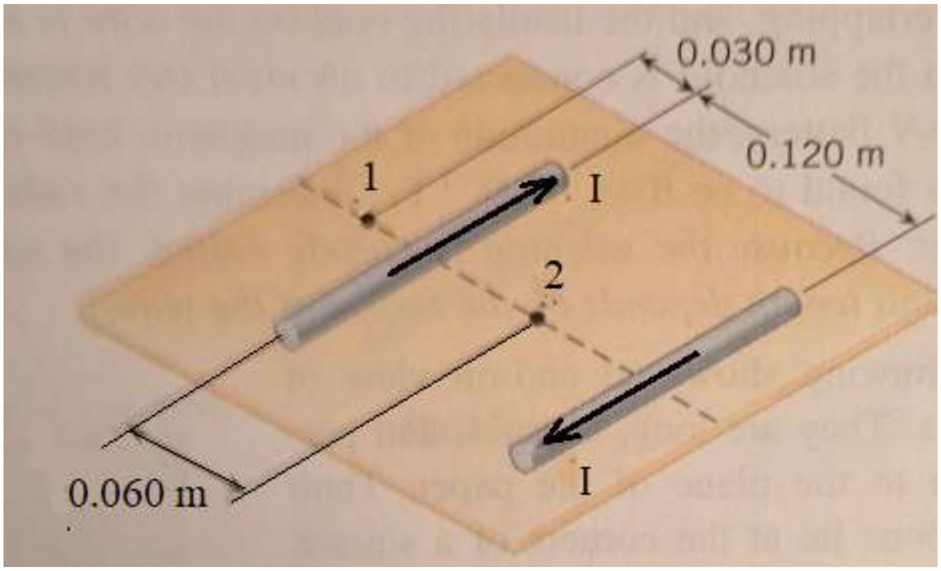
13. What must be the radius of a circular loop of wire so the magnetic field at its center is 1.8 x 10^{-4} T when the loop carries a current of 12 A?

14. Two perpendicular circular rings of wire have the same radius of 0.06 m and a common center. Each ring carries a current of 2.0 A. What is the magnitude of the net magnetic field at the common center?

15. The drawing shows four long, insulated wires overlapping one another, forming a square with 0.060 m sides. The net magnetic field at the center of the square is 60 µT. Calculate the current I.



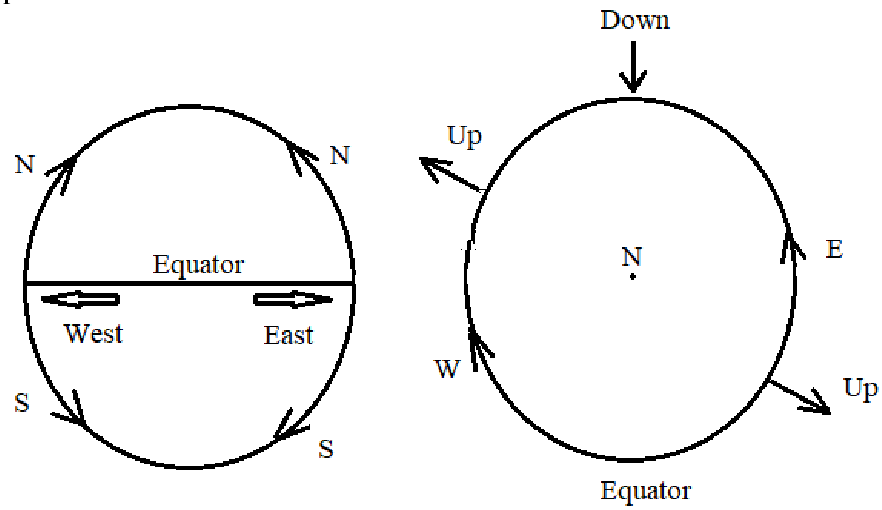
16. Two long, straight wires are separated by 0.120 m. The wires carry currents of 8.0 A in opposite directions, as the drawing indicates. Find the absolute value of the magnetic field at the points labeled (a) 2, and (b) 1.



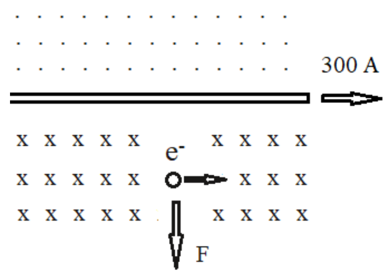
17. In a lightning bolt, 15.0 C of charge flows during a time of 1.5×10^{-3} s. Assuming that the lightning bolt can be represented as a long, straight current-carrying wire, what is the current's magnetic field, in gauss, at a distance of 25 m from the bolt? Compare this to Earth's magnetic field near the ground, 0.5 G.

Solutions

The diagrams below indicate the various directions discussed in right-hand-rule problems.



<table>
<tr>
<td>1. away from the observer (The back of the observer's hand points away from her.</td>
<td rowspan="4">6. Current-Carrying Ring:
$B = 4000$ G
$= 0.4000$ T
$B = 1000\ \mu_o I/2R$
$0.40 = 1000\ (4\pi \times 10^{-7})\ I/[2\ (0.04)]$

$I = 25.46$ A</td>
<td rowspan="5">7.


$B = \mu_o I/2\pi r$
$= 4\pi\ (300)/2\pi\ (0.04)$
$= 0.0015$ T
$F = evB \sin 90$
$= 1.6 \times 10^{-19}\ (2 \times 10^{6})\ (0.0015)$
$= 4.8 \times 10^{-16}$ N</td>
</tr>
<tr>
<td>2. Palm faces away from the ground: upward</td>
</tr>
<tr>
<td>3. Palm faces eastward</td>
</tr>
<tr>
<td>4. Back of hand faces westward</td>
</tr>
<tr>
<td>5. If viewer sees couNter-clockwise current, she sees North; otherwise, she sees South.</td>
<td>8. MODE: Degree

$F = QvB \sin\theta$
$= (1.6\text{x}10^{-19})\ (5\text{x}10^{6})\ (0.4) \sin 30$
$= 1.6 \times 10^{-13}$ N

$a = F/m$
$= 1.6 \times 10^{-13}/1.67 \times 10^{-27}$
$= 9.58 \times 10^{13}$ m/s^2</td>
</tr>
</table>

9.

The radius of the circular orbit of a charged Q moving in a magnetic field is given below:

$r = mv/QB$

Students are expected to know how to derive this equation.

$r = mv/eB$

$v = eBr/m$

$= 1.6 \times 10^{-19} (0.30)(0.25)/1.67 \times 10^{-27}$

$= 7.2 \times 10^{6}$ m/s

10. The radius of the circular orbit of a charged Q moving in a magnetic field is given below:

$r = mv/QB$

In this case, the object is a proton, so Q = e.

The values of m, e, and B are known:

$m = 9.11 \times 10^{-31}$ kg

$e = 1.6 \times 10^{-19}$ C

$B = 5.3 \times 10^{-5}$ T

We need to calculate v:

$\frac{1}{2} mv^2 = 2.0 \times 10^{-17}$ J

$\frac{1}{2} (9.11 \times 10^{-31})v^2 = 2.0 \times 10^{-17}$

Solve for v:

$v = 6.63 \times 10^{6}$ m/s

$r = mv/eB$

$= (9.11 \times 10^{-31})(6.63 \times 10^{6}) / (1.6 \times 10^{-19} \times 5.3 \times 10^{-5})$

$= 0.71$ m

11. $F = ILB \sin \theta$ MODE: Degree

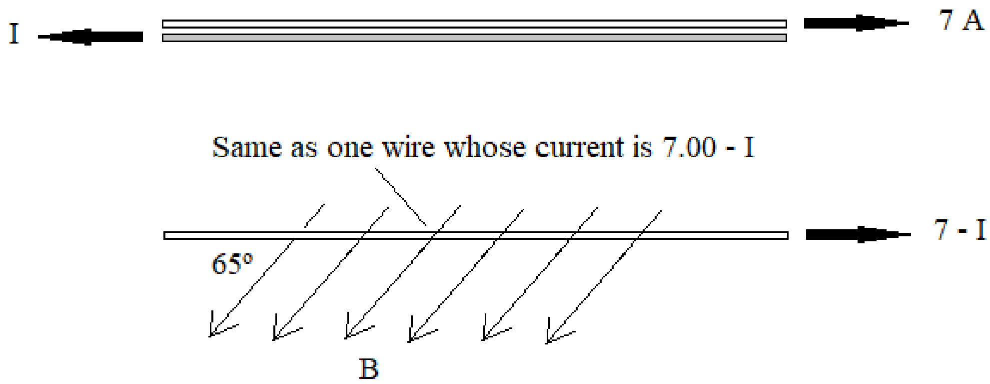
$B = F/(IL \sin \theta)$

$= 0.15/ [75 (45) \sin 60$

$= 5.13 \times 10^{-5}$ T

$= 0.513$ G

12. $F = ILB \sin\theta$
$L = 2.40$ m
$B = 0.360$ T
$\theta = 65$
$F = 3.13$ N



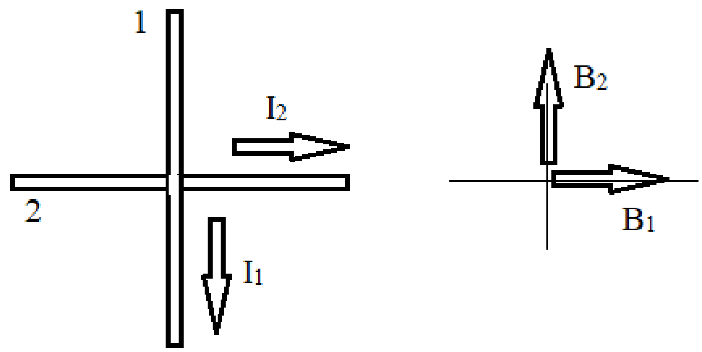
MODE: Degree

$$F = (7 - I)\, LB \sin\theta$$
$$3.13 = (7 - I)\,(2.40)\,(0.360) \sin 65$$
$$I = 3.00 \text{ A}$$

13. What must be the radius of a circular loop of wire so the magnetic field at its center is 1.8×10^{-4} T when the loop carries a current of 12 A.

$B = \mu_o I/2r$
$1.8 \times 10^{-4} = 4\pi \times 10^{-7}\,(12)/2r$
$r = 0.04$ m

14.



Magnetic field at the center due to one of the rings:

$B = \mu_o I/(2R)$
$= \mu_o(2.0)/ [2(0.06)]$
$= 2.09 \times 10^{-5}$ T

The other ring has the same B at the center, and the two B-vectors are perpendicular. The sum of two perpendicular vectors is the square-root of the sum of the squares.

$[(2.09 \times 10^{-5})^2 + (2.09 \times 10^{-5})^2]^{1/2} = 2.96 \times 10^{-5}$ T

15. The three known currents each create a magnetic field intensity B that points <u>into</u> the plane of the square. The unknown current I creates a magnetic field that points out of the plane, in the opposite direction:

The distance of each wire from the center of the square is:

$r = ½ (0.06$ m$)$
$= 0.03$ m

$\mu_o(3 + 6 + 8 - I)/ 2\pi (0.03) = 60 \times 10^{-6}$
Solve for I:
I = 8 A

16.

(a) The fields at Point 2 add, so just double one of the B's:

$B = 2 \mu_o(8)/[2\pi(0.06)]$
$= 5.33 \times 10^{-5}$ T

(b) At Point 1, the fields point in opposite directions. Instead of using the arbitrary rule that "in" is positive and "out" is negative, we will just subtract the smaller B from the larger one to get the absolute value of the net field:

$B = \mu_o(8)/[2\pi(0.03)] - \mu_o(8)/[2\pi(0.15)]$
$= 4.27 \times 10^{-5}$ T

17. $I = Q/t$

$= 15/1.5\text{x}10^{-3}$

$= 1.0 \times 10^{4}$ A

$B = \mu_o (1.0 \times 10^{4}) / 2\pi (25)$

$= 8.00 \times 10^{-5}$ T

$= 0.80 \times 10^{-4}$ T

$= 0.80$ G

This is about 1.6 times Earth's field near the ground.