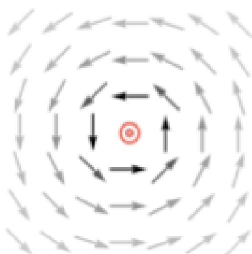
CH 19-1 – Magnetic Field

Important Ideas

- A moving charged particle creates a magnetic field everywhere in space around it. If the particle has a velocity $\vec{v}$, then the magnetic field at this instant is tangent to a circle around the axis of $\vec{v}$. The direction of the magnetic field created by a moving charged particle is given by the right hand rule for this case. For $+q$, point your thumb in the direction of $\vec{v}$, and $\vec{B}$ is tangent to a circle around $\vec{v}$ in the direction that your fingers curl around your thumb.

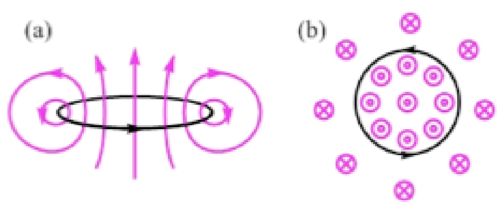
  

  If the particle has charge $-q$, then use your left hand because $\vec{B}$ is in the opposite direction. For a current-carrying wire, the conventional current is in the direction of the velocity of positive charge, so point your thumb in the direction of I and your fingers curl around the wire in the direction of the magnetic field. The magnetic field due to a very long wire at a perpendicular distance r from the wire is:

  $$B = \frac{\mu_0 I}{2\pi r}$$

  where $\mu_0 = 4\pi \times 10^{-7}$ T m/A.

- For current flowing around a loop of wire, the net magnetic field (due to each small piece of the wire) at the center of the loop is along the axis of the loop, perpendicular to the plane of the loop. Its direction is given by the right-hand rule for current loops. Curl your fingers around the loop in the direction that current flows in the loop. Your thumb points in the direction of the magnetic field along the axis of the loop.

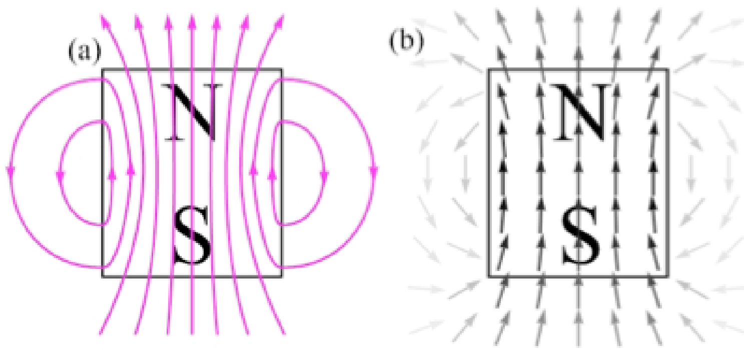
  

  The magnetic field at the center of a loop of wire of radius R is

  $$B = \frac{\mu_0 I}{2R}$$

- A compass needle can be used to determine the direction of magnetic field because a compass needle points in the direction of $\vec{B}$.

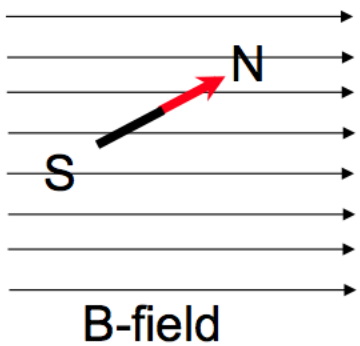
- A dipole magnet has a N pole and S pole. N and S poles always come in pairs–you will not find one without the other. Outside the magnet, magnetic field at locations along the axis of the dipole points away from N and toward S.



At points along the perpendicular bisector, magnetic field points in the opposite direction as the magnetic field along the axis of the dipole.

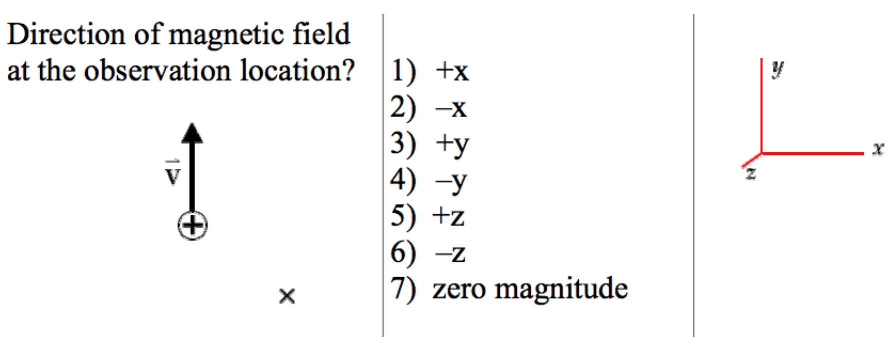
Examples

1. A dipole is released from rest in a uniform magnetic field shown below.



After the oscillations dampen, in what direction will the dipole point?

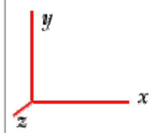
2.



3.

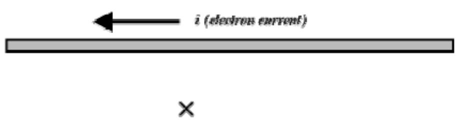
At the observation location the magnetic field due to the proton is in the -y direction. What is a possible direction for the velocity of the proton?

1) +x
2) –x
3) +y
4) –y
5) +z
6) –z
7) zero magnitude

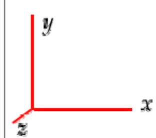


4.

Direction of magnetic field at the observation location?

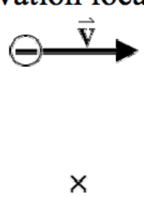


1) +x
2) –x
3) +y
4) –y
5) +z
6) –z
7) zero magnitude

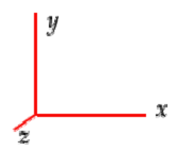


5.

Direction of magnetic field at the observation location?



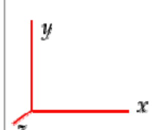
1) +x
2) –x
3) +y
4) –y
5) +z
6) –z
7) zero magnitude



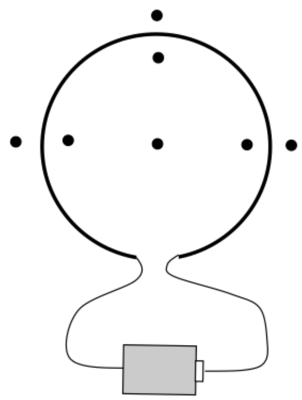
6.

At the observation location the magnetic field due to the ***electron*** is in the -z direction. What is a possible direction for the velocity of the ***electron***?

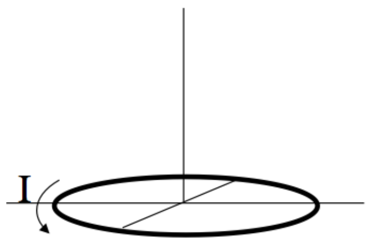
1) +x
2) –x
3) +y
4) –y
5) +z
6) –z
7) zero magnitude



7. What is the direction of the magnetic field at each of the points shown, due to current in the loop?

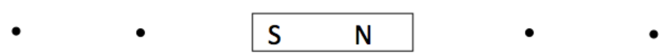


8. What is the direction of the magnetic field along the axis of the loop?



9. For the loop in the previous question, indicate the N side of the loop and the S side of the loop and sketch a dipole magnet that would give the same magnetic field as the loop.

10. Sketch the magnetic field at each point due to the magnetic dipole.



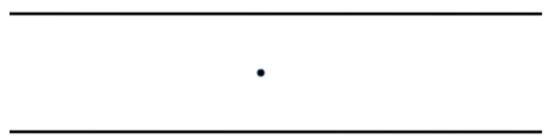
11. The horizontal component of Earth's magnetic field at locations for most of the U.S. is 2×10^{-5} T. If a wire carries a current of 2 A, how far from the wire will the magnetic field due to the current in the wire be equal in magnitude to the horizontal component of Earth's magnetic field?

12. A single loop of wire carries a current of 0.5 A, clockwise around the loop (if facing the loop). The loop has a radius of 2 cm.

    (a) What is the magnetic field at its center?

    (b) If you have a coil with 100 turns (i.e. loops) that carries the same current, 0.5 A, what is the magnetic field at its center?

13. Two parallel wires carry current, as shown below. The current in the top wire is 1 A to the right and the current in the bottom wire is 1 A to the left. the distance between the wires is 2 cm.

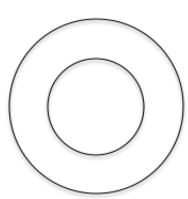


    (a) What is the direction of the net magnetic field at a point halfway between the wires?

    (b) At a point 0.5 cm from the top wire, what is the direction and magnetic of the net magnetic field?

    (c) If the current in the wires are both to the right, what is the direction of the net magnetic field at a point halfway between the wires?

14. Two concentric loops of radii 1 cm and 2 cm, respectively, carry current as shown below. In the inner loop, there is a current of 2 A clockwise. In the outer loop, there is a current of 2 A counterclockwise.



    (a) If the magnetic field at the center of the inner loop is B_0, what is the magnetic field at the center due to the outer loop?

    (b) In what direction is the net magnetic field at the center?

    (c) Calculate the net magnetic field at the center.