Chapters 22

Terms

Be able to define or discuss the following terms and ideas, with their SI units if appropriate.

1. magnetic dipole
2. magnetic field
3. right-hand rule for a current-carrying wire (to find the direction of magnetic field at points around a current carrying wire)
4. right-hand rule for a moving proton; left-hand rule for a moving electron (to find the magnetic field due to a moving charged particle)
5. electromagnet (current-carrying loop or coil)
6. magnetic dipole moment μ
7. right-hand rule for a current in a wire loop or coil (to find the direction of the magnetic field along the axis of the loop or coil)
8. N and S poles of a dipole
9. N and S poles of an electromagnet
10. magnetic force on a moving charged particle by a magnetic field
11. right-hand rule for magnetic force (to find the magnetic force on a moving charged particle or on a current-carrying wire)
12. uniform circular motion of a charged particle in a magnetic field
13. velocity selector
14. torque on a magnetic dipole in a magnetic field
15. an electric motor
16. attraction and repulsion of magnetic dipoles
17. MRI

Equations

Understand the meaning and know the SI units of all symbols in these equations; know how to perform each mathematical operation, such as trig functions; know how to solve for any unknown quantity; understand how changing one quantity affects another quantity (if all other quantities remain constant); be able to apply one or more equations to solve a problem.

- Magnetic field at a perpendicular distance r from a long, straight wire:

$$B = \frac{\mu_0}{4\pi}\frac{2I}{r}$$

- Magnetic field at a distance r from a current-carrying loop, along the axis of the loop (if the distance r is much greater than the radius of the loop):

$$B \approx \frac{\mu_0}{4\pi} \frac{2IA}{r^3}$$

  Note: For a coil, multiple the magnetic field by N, the number of loops in the coil. The magnetic dipole moment of a loop is $\mu = IA$ and for a coil is $\mu = NIA$.

- Magnetic field at a distance r from a magnetic dipole with dipole moment μ, along the:

$$B \approx \frac{\mu_0}{4\pi} \frac{2\mu}{r^3}$$

- Magnitude of the magnetic force on a moving charged particle:

$$F = |q|vB\sin\theta$$

- Magnitude of the magnetic force on a current-carrying wire:

$$F = ILB\sin\theta$$

- Radius of circular motion of a charged particle in a magnetic field:

$$R = \frac{mv}{qB}$$

- Velocity selector; if the net force on a charged particle due to crossed electric and magnetic fields is zero, then the particle's velocity is constant (i.e. uniform):

$$v = \frac{E}{B}$$

- Magnetic torque on a magnetic dipole in a magnetic field:

$$\tau = \mu B\sin\theta$$

- Magnetic torque on a current-carrying coil in a magnetic field:

$$\tau = NIAB\sin\theta$$

Skills

1. Determine the direction of the magnetic field along the axis of a magnetic dipole if given the N and S poles of the dipole.
2. Determine the direction of the magnetic field along the axis of a current-carrying loop if given the direction of the current through the loop.
3. Determine the direction of the magnetic field at any given point in space due to a moving charged particle (for both negative and positively charged particles)
4. Calculate the magnetic field at a given location in space due to a long, current-carrying wire.
5. Calculate the magnetic field along the axis of a current-carrying loop or coil, at points far from the coil.
6. Predict whether a current-carrying loop and a dipole magnet aligned with the axis of the loop will attract or repel.
7. Determine the direction of a magnetic force on a moving charged particle by a magnetic field.
8. Predict the path that a charged particle will travel in a uniform magnetic field; know that it travels in uniform circular motion and predict which direction it will move around the circle, given the directions of the initial velocity and the magnetic field.
9. Use Newton's second law applied to uniform circular motion to derive an equation for the radius of the circular path for a charged particle moving in uniform magnetic field.
10. Sketch force vectors for the electrostatic (i.e Coulomb) and magnetic forces on a charged particle moving in a region of crossed electric and magnetic fields.
11. Calculate the speed of a particle which moves through a region of crossed electric and magnetic fields with uniform motion.
12. Describe which direction a magnetic dipole will rotate when it is in a uniform magnetic field, given the orientation of the magnetic dipole.
13. Know that a magnetic dipole released from rest in a uniform magnetic field will oscillate about the magnetic field.
14. Describe which direction a current-carrying loop will rotate when it is in a uniform magnetic field, given the orientation of the magnetic dipole.
15. Know that a current-carrying loop released from rest in a uniform magnetic field will oscillate about the magnetic field.
16. Describe the essential components, the purpose, and operation of an electric motor.
17. Calculate the torque on a magnetic dipole or current-carrying loop (or coil) in a uniform magnetic field.

Lab Skills

1. Use a compass to determine the N and S poles of a magnetic dipole.
2. Use θ (the deflection of a compass needle from N) to determine the magnitude of an applied magnetic field that is on the E-W axis; sketch a right triangle showing the magnetic field of Earth, the applied magnetic field (in the E or W direction), and the deflection angle; use trigonometry to solve for the applied magnetic field.

3. Sketch a graph of magnetic field vs. current; use the constant of the curve-fit to determine the distance r of the point where the magnetic field was measured.
4. Sketch a graph of magnetic field vs. distance r from the wire for a current I flowing through the wire; use the constant of proportionality to determine the current flowing through the wire.
5. For a given current flowing through a coil, describe whether a magnetic dipole on the axis of the coil will be attracted or repelled.
6. Describe the essential parts and operation of an audio speaker.