Chapter 19
Magnetism

Quick Quizzes

1. (b). The force that a magnetic field exerts on a charged particle moving through it is given by $F = qvB\sin\theta = qvB_\perp$, where $B_\perp$ is the component of the field perpendicular to the particle's velocity. Since the particle moves in a straight line, the magnetic force (and hence $B_\perp$, since $qv \neq 0$) must be zero.

2. (c). The magnetic force exerted by a magnetic field on a charge is proportional to the charge's velocity relative to the field. If the charge is stationary, as in this situation, there is no magnetic force.

3. (c). The torque that a planar current loop will experience when it is in a magnetic field is given by $\tau = BIA\sin\theta$. Note that this torque depends on the strength of the field, the current in the coil, the area enclosed by the coil, and the orientation of the plane of the coil relative to the direction of the field. However, it *does not depend on the shape* of the loop.

4. (a). The magnetic force acting on the particle is always perpendicular to the velocity of the particle, and hence to the displacement the particle is undergoing. Under these conditions, the force does no work on the particle and the particle's kinetic energy remains constant.

5. (b). The two forces are an action-reaction pair. They act on different wires and have equal magnitudes but opposite directions.

Answers to Even Numbered Conceptual Questions

2. No. The force that a constant magnetic field exerts on a charged particle is dependent on the velocity of that particle. If the particle has zero velocity, it will experience no magnetic force and cannot be set in motion by a constant magnetic field.

4. The force exerted on a current-carrying conductor by a magnetic field is $F = BI\ell \sin\theta$, where θ is the angle between the direction of the current and the direction of the magnetic field. Thus, if the current is in a direction parallel $(\theta = 0)$ or anti-parallel $(\theta = 180°)$ to the magnetic field, there is no magnetic force exerted on the conductor.

6. Straight down toward the surface of Earth.

8. The magnet causes domain alignment in the iron such that the iron becomes magnetic and is attracted to the original magnet. Now that the iron is magnetic, it can produce an identical effect in another piece of iron.

10. The magnet produces domain alignment in the nail such that the nail is attracted to the magnet. Regardless of which pole is used, the alignment in the nail is such that it is attracted to the magnet.

12. The magnetic field inside a long solenoid is given by $B = \mu_0 nI = \mu_0 NI/\ell$.

    (a) If the length ℓ of the solenoid is doubled, the field is cut in half.

    (b) If the number of turns, *N*, on the solenoid is doubled, the magnetic field is doubled.

14. Near the poles the magnetic field of Earth points almost straight downward (or straight upward), in the direction (or opposite to the direction) the charges are moving. As a result, there is little or no magnetic force exerted on the charged particles at the pole to deflect them away from Earth.

16. The loop can be mounted on an axle that can rotate. The current loop will rotate when placed in an external magnetic field for some arbitrary orientation of the field relative to the loop. As the current in the loop is increased, the torque on it will increase.

18. Yes. If the magnetic field is directed perpendicular to the plane of the loop, the forces on opposite sides of the loop will be equal in magnitude and opposite in direction, but will produce no net torque on the loop.

20. No. The magnetic field created by a single current loop resembles that of a bar magnet – strongest inside the loop, and decreasing in strength as you move away from the loop. Neither is the field uniform in direction – the magnetic field lines loop through the loop.

22. **(a)** The magnets repel each other with a force equal to the weight of one of them.

    (b) The pencil prevents motion to the side and prevents the magnets from rotating under their mutual torques. Its constraint changes unstable equilibrium into stable.

    (c) Most likely, the disks are magnetized perpendicular to their flat faces, making one face a north pole and the other a south pole. One disk has its north pole on the top side and the other has its north pole on the bottom side.

    (d) Then if either were inverted they would attract each other and stick firmly together.

Answers to Even Numbered Problems

2. **(a)** (a′) to the left; (b′) into the page; (c′) out of the page; (d′) toward the top; (e′) into the page; (f′) out of the page
(b) All answers are the reverse of those given in **(a)**.

4. **(a)** toward the top of the page **(b)** out of the page
(c) zero force **(d)** into the page

6. 4.96×10^{-17} N southward

8. **(a)** 7.90×10^{-12} N **(b)** 0

10. 806 N

12. **(a)** to the left **(b)** into the page **(c)** out of the page
(d) toward top of page **(e)** into the page **(f)** out of the page

14. 0.245 T eastward

16. **(a)** 9.0×10^{-3} N at 15° above horizontal in northward direction
(b) 2.3×10^{-3} N horizontal and due west

18. 0.109 A toward the right

20. **(a)** 4.73 N **(b)** 5.46 N **(c)** 4.73 N

22. 4.33×10^{-3} N·m

24. 10 N·m, clockwise (as viewed from above the loop)

26. 118 N·m

28. 7.88×10^{-12} T

30. 0.150 mm

32. 3.11 cm

34. **(a)** toward the left **(b)** out of the page **(c)** lower left to upper right

36. 675 A, conventional current is downward or negative charges flow upward

38. **(a)** 40.0 μT into the page **(b)** 5.00 μT out of the page
(c) 1.67 μT out of the page