

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. (a) and (c). The magnitude of the force per unit length between two parallel current carrying wires is $F/\ell = (\mu_0 I_1 I_2)/(2\pi d)$. The magnitude of this force can be doubled by doubling the magnitude of the current in either wire. It can also be doubled by decreasing the distance between them, d , by half. Thus, both choices (a) and (c) are correct.
6. (b). The two forces are an action-reaction pair. They act on different wires and have equal magnitudes but opposite directions.

ANSWERS TO MULTIPLE CHOICE QUESTIONS

1. The electron moves in a horizontal plane in a direction of 35° N or E, which is the same as 55° E of N. Since the magnetic field at this location is horizontal and directed due north, the angle between the direction of the electron's velocity and the direction of the magnetic field is 55° . The magnitude of the magnetic force experienced by the electron is then

$$F = |q|vB\sin\theta = (1.6 \times 10^{-19} \text{ C})(2.5 \times 10^6 \text{ m/s})(0.10 \times 10^{-4} \text{ T})\sin 55^\circ = 3.3 \times 10^{-18} \text{ N}$$

The right-hand rule number 1 predicts a force directed upward, away from the Earth's surface for a positively charged particle moving in the direction of the electron. However, the *negatively charged* electron will experience a force in the opposite direction, downward *toward* the Earth's surface. Thus, the correct choice is (d).

2. If the magnitude of the magnetic force on the wire equals the weight of the wire, then $BI\ell\sin\theta = w$, or $B = w/I\ell\sin\theta$. The magnitude of the magnetic field is a minimum when $\theta = 90^\circ$ and $\sin\theta = 1$. Thus,

$$B_{\min} = \frac{w}{I\ell} = \frac{1.0 \times 10^{-2} \text{ N}}{(0.10 \text{ A})(0.50 \text{ m})} = 0.20 \text{ T}$$

and (a) is the correct answer for this question.

3. The z -axis is perpendicular to the plane of the loop, and the angle between the direction of this normal line and the direction of the magnetic field is $\theta = 30.0^\circ$. Thus, the magnitude of the torque experienced by this coil containing $N = 10$ turns is

$$\tau = BIAN\sin\theta = (0.010 \text{ T})(2.0 \text{ A})[(0.20 \text{ m})(0.30 \text{ m})](10)\sin 30.0^\circ = 6.0 \times 10^{-3} \text{ N}\cdot\text{m}$$

meaning that (c) is the correct choice.

4. A charged particle moving perpendicular to a magnetic field experiences a centripetal force of magnitude $F_c = mv^2/r = qvB$ and follows a circular path of radius $r = mv/qB$. The speed of this proton must be

$$v = \frac{qBr}{m} = \frac{(1.6 \times 10^{-19} \text{ C})(0.050 \text{ T})(1.0 \times 10^{-3} \text{ m})}{1.67 \times 10^{-27} \text{ kg}} = 4.8 \times 10^3 \text{ m/s}$$

and choice (e) is the correct answer.

5. The magnitude of the magnetic field at distance r from a long straight wire carrying current I is $B = \mu_0 I / 2\pi r$. Thus, for the described situation,

$$B = \frac{(4\pi \times 10^{-7} \text{ T}\cdot\text{m/A})(1 \text{ A})}{2\pi(2 \text{ m})} = 1 \times 10^{-7} \text{ T}$$

making (d) the correct response.

6. The force per unit length between this pair of wires is

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi d} = \frac{(4\pi \times 10^{-7} \text{ T}\cdot\text{m/A})(3 \text{ A})^2}{2\pi(2 \text{ m})} = 9 \times 10^{-7} \text{ N} - 1 \times 10^{-6} \text{ N}$$

and (d) is the best choice for this question.

7. The magnitude of the magnetic field inside the specified solenoid is

$$B = \mu_0 nI = \mu_0 \left(\frac{N}{\ell}\right)I = (4\pi \times 10^{-7} \text{ T}\cdot\text{m/A})\left(\frac{120}{0.50 \text{ m}}\right)(2.0 \text{ A}) = 6.0 \times 10^{-4} \text{ T}$$

which is choice (e).

8. The magnitude of the magnetic force experienced by a charged particle in a magnetic field is given by $F = qvB \sin \theta$, where v is the speed of the particle and θ is the angle between the direction of the particle's velocity and the direction of the magnetic field. If either $v = 0$ [choice (e)] or $\sin \theta = 0$ [choice (c)], this force has zero magnitude. All other choices are false, so the correct answers are (c) and (e).
9. The force that a magnetic field exerts on a moving charge is always perpendicular to both the direction of the field and the direction of the particle's motion. Since the force is perpendicular to the direction of motion, it does no work on the particle and hence does not alter its speed. Because the speed is unchanged, both the kinetic energy and the magnitude of the linear momentum will be constant. Correct answers among the list of choices are (d) and (e). All other choices are false.
10. By the right-hand rule number 1, when the proton first enters the field, it experiences a force directed upward, toward the top of the page. This will deflect the proton upward, and as the proton's velocity changes direction, the force changes direction always staying perpendicular to the velocity. The force, being perpendicular to the motion, causes the particle to follow a circular path, with no change in speed, as long as it is in the field. After completing a half circle, the proton will exit the field traveling toward the left. The correct answer is choice (d).
11. The contribution made to the magnetic field at point P by the lower wire is directed out of the page, while the contribution due to the upper wire is directed into the page. Since point P is equidistant from the two wires, and the wires carry the same magnitude currents, these two oppositely directed contributions to the magnetic field have equal magnitudes and cancel each other. Therefore, the total magnetic field at point P is zero, making (a) the correct answer for this question.
12. The magnetic field due to the current in the vertical wire is directed into the page on the right side of the wire and out of the page on the left side. The field due to the current in the horizontal wire is out of the page above this wire and into the page below the wire. Thus, the two contributions to the total magnetic field have the same directions at points B (both out of the page) and D (both contributions into the page), while the two contributions have opposite directions at points A and C. The magnitude of the total magnetic field will be greatest at points B and D where the two contributions are in the same direction, and smallest at points A and C where the two contributions are in opposite directions and tend to cancel. The correct choices for this question are (a) and (c).
13. Any point in region I is closer to the upper wire which carries the larger current. At all points in this region, the outward directed field due the upper wire will have a greater magnitude than will the inward directed field due to the lower wire. Thus, the resultant field in region I will be nonzero and out of the page, meaning that choice (d) is a true statement and choice (a) is false. In region II, the field due to each wire is directed into the page, so their magnitudes add and the resultant field cannot be zero at any point in this region. This means that choice (b) is false. In region III, the field due to the upper wire is directed into the page while that due to the lower wire is out of the page. Since points in this region are closer to the wire carrying the smaller current, there are points in this region where the magnitudes of the oppositely directed fields due to the two wires will have equal magnitudes, canceling each other and producing a zero resultant field. Thus, choice (c) is true and choice (e) is false. The correct answers for this question are choices (c) and (d).
14. The torque exerted on a single turn coil carrying current I by a magnetic field B is $\tau = BIA \sin \theta$. The line perpendicular to the plane of each coil is also perpendicular to the direction of the magnetic field (i.e., $\theta = 90^\circ$). Since B and I are the same for all three coils, the torques exerted on them are proportional to the area A enclosed by each of the coils. Coil A is rectangular with area $A_A = (1 \text{ m})(2 \text{ m}) = 2 \text{ m}^2$. Coil B is elliptical with semi-major axis $a = 0.75 \text{ m}$ and