1. B To solve this problem, it is helpful to remember how the magnetic field lines around a bar magnet look:The arrows of the magnetic field lines show the direction toward which a north magnetic pole would be attracted. Since the compass needle is a south magnetic pole, it’s attracted in the opposite direction of the field lines.Note that the correct answer is B, and not E. The magnet points along the magnetic field lines, and not straight at the north pole of the magnet.

2. A This question demands that we apply the right-hand rule backward. Force, velocity, and magnetic strength are related by the formula . Since the particle is positively charged, q is positive, and the F vector will point in the same direction as the vector.Let’s imagine the particle at the six o’clock position. That means the particle is moving to the left, so stretch your fingers in the leftward direction. It’s moving under the influence of a centripetal magnetic force that pulls it in a circle. This force is directed toward the center of the circle, so point your thumb upward toward the center of the imaginary clock face. To do this, you’ll have to have your palm facing up, and you’ll find that when you curl your fingers around, they point out of the plane of the page. That’s the direction of the magnetic field lines.

3. A The magnetic force experienced by a moving particle is given by the formula . Since F is proportional to the cross product of v and B, we can maximize F by maximizing v and B, and by ensuring that v and B are perpendicular to one another. According to these requirements, only statement I will maximize the magnetic force: both statements II and III will serve to minimize the magnetic force.

4. B Magnetic force is related to charge, velocity, and magnetic field strength by the formula . Since the velocity vector and the magnetic field strength vector are perpendicular, we can calculate the magnitude of the magnetic force quite easily:The minus sign in the answer signifies the fact that we are dealing with a negatively charged particle. That means that the force is in the opposite direction of the vector. We can determine the direction of this vector using the right-hand rule: point your fingers upward in the direction of the v vector and curl them downward in the direction of the B vector; your thumb will be pointing to the left. Since we’re dealing with a negatively charged particle, it will experience a force directed to the right.

5. B If the particle is moving in a circular orbit, its velocity is perpendicular to the magnetic field lines, and so the magnetic force acting on the particle has a magnitude given by the equation F = qvB. Since this force pulls the particle in a circular orbit, we can also describe the force with the formula for centripetal force: F = mv2/r. By equating these two formulas, we can get an expression for orbital radius, r, in terms of magnetic field strength, B:Since magnetic field strength is inversely proportional to orbital radius, doubling the magnetic field strength means halving the orbital radius.

6. D When a charged particle moves in the direction of the magnetic field lines, it experiences no magnetic force, and so continues in a straight line, as depicted in A and B. When a charged particle moves perpendicular to the magnetic field lines, it moves in a circle, as depicted in C. When a charged particle has a trajectory that is neither perfectly parallel nor perfectly perpendicular to the magnetic field lines, it moves in a helix pattern, as depicted in E. However, there are no circumstances in which a particle that remains in a uniform magnetic field goes from a curved trajectory to a straight trajectory, as in D.

7. C The electric field will pull the charged particle to the left with a force of magnitude F = qE. The magnetic field will exert a force of magnitude F = qvB. The direction of this force can be determined using the right-hand rule: extend your fingers upward in the direction of the velocity vector, then point them out of the page in the direction of the magnetic field vector. You will find your thumb is pointing to the right, and so a positively charged particle will experience a magnetic force to the right.If the particle is to move at a constant velocity, then the leftward electric force must be equal in magnitude to the rightward magnetic force, so that the two cancel each other out:

8. D The magnetic force, F, due to a magnetic field, B, on a current-carrying wire of current I and length l has a magnitude F = IlB. Since F is directly proportional to I, doubling the current will also double the force.

9. B Each wire exerts a magnetic force on the other wire. Let’s begin by determining what force the lower wire exerts on the upper wire. You can determine the direction of the magnetic field of the lower wire by pointing the thumb of your right hand in the direction of the current, and wrapping your fingers into a fist. This shows that the magnetic field forms concentric clockwise circles around the wire, so that, at the upper wire, the magnetic field will be coming out of the page. Next, we can use the right-hand rule to calculate the direction of the force on the upper wire. Point your fingers in the direction of the current of the upper wire, and then curl them upward in the direction of the magnetic field. You will find you thumb pointing up, away from the lower wire: this is the direction of the force on the upper wire.If you want to be certain, you can repeat this exercise with the lower wire. The easiest thing to do, however, is to note that the currents in the two wires run in opposite directions, so whatever happens to the upper wire, the reverse will happen to the lower wire. Since an upward force is exerted on the upper wire, downward force will be exerted on the lower wire. The resulting answer, then, is B.

10. C There are two magnetic fields in this question: the uniform magnetic field and the magnetic field generated by the current-carrying wire. The uniform magnetic field is the same throughout, pointing into the page. The magnetic field due to the current-carrying wire forms concentric clockwise circles around the wire, so that they point out of the page above the wire and into the page below the wire. That means that at points A and B, the upward magnetic field of the current-carrying wire will counteract the downward uniform magnetic field. At points C and D, the downward magnetic field of the current-carrying wire will complement the downward uniform magnetic field. Since the magnetic field due to a current-carrying wire is stronger at points closer to the wire, the magnetic field will be strongest at point C.