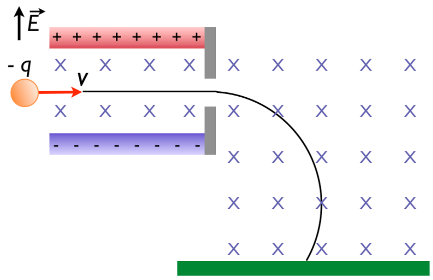
Name & ID

PH 102 / LeClair Summer II 2010

Quiz 5: Solutions



1. The figure at left shows a simplified mass spectrometer. Particles with charge q and mass m enter at left with a velocity v, and encounter a region with both an E and B field as shown. What is the relationship between v, B, and E for particles that make it through the aperture in the middle of the detector?

Solution: In the leftmost region of the device, the particles travel in a straight line, which means they have no net acceleration. The particles are acted on by a magnetic force of magnitude qvB, and an electric force of magnitude qE in opposite directions. For no net acceleration, the two forces must balance:

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

2. Consider a proton moving with a speed of $1 \cdot 10^5$ m/s through the earth's magnetic field ($|\vec{\mathbf{B}}| = 55\,\mu\text{T}$). When the proton moves east, the magnetic force acts straight upward. When the proton moves northward, no force acts on it. What is the direction of the magnetic field? (*Note:* $\mu = 10^{-6}$.)

Solution: The proton will experience no force when it is moving in a direction parallel to the magnetic field. We already know then that the magnetic field is either pointing north or south, since the proton experiences no force when traveling north. But is it north or south?

When the proton moves east, it experiences a force upward. We can use the first right-hand rule to find definitively the direction of the $\vec{\mathbf{B}}$ field. Put the fingers of your right hand along the proton's velocity (east), and point the back of your hand in the direction of the resulting force (up). Your right thumb now points along the direction of $\vec{\mathbf{B}}$ - north.

3. Two wires run parallel to each other and carry currents of 15 A in the same direction. What is the magnetic field halfway between the two wires?

Solution: When the currents in the wires are parallel, their fields are in opposite directions in between the two wires. Halfway between, the distance from each wire is the same, so the fields will be of equal magnitude and in opposite directions. Thus, the total field is zero.