**9. Magnetism – Tutorial 9**

**9.1** What is the acceleration of a proton moving with a speed of 9.5 m/s at right angles to a magnetic field of 1.6 T? \((1.5 \times 10^9 \text{ m/s}^2)\)

**9.2** An electron moves at right angles to a magnetic field of 0.12 T. What is its speed if the force exerted on it is \(8 \times 10^{-15} \text{ N}\)? \((4.6 \times 10^5 \text{ m/s})\)

**9.3** A negatively charged ion moves due north with a speed of \(1.5 \times 10^6 \text{ m/s}\) at the Earth’s equator. What is the magnetic force exerted on this ion? \((0)\)

**9.4** A proton high above the equator approaches the Earth moving straight downward with a speed of 355 m/s. Find the acceleration of the proton, given that the magnetic field at its altitude is \(4.05 \times 10^{-5} \text{ T}\). \((1.36 \times 10^6 \text{ m/s}^2)\)

**9.5** A 0.32-\(\mu\)C particle moves with a speed of 16 m/s through a region where the magnetic field has a strength of 0.95 T. At what angle to the field is the particle moving if the force exerted on it is (a) \(4.8 \times 10^{-6} \text{ N}\), (b) \(3.0 \times 10^{-6} \text{ N}\), or (c) \(1.0 \times 10^{-7} \text{ N}\)\? \((81^\circ, 38^\circ, 1.2^\circ)\)

**9.6** A particle with a charge of 14\(\mu\)C experiences a force of \(2.2 \times 10^{-4} \text{ N}\) when it moves at right angles to a magnetic field with a speed of 27 m/s. What force does this particle experience when it moves with a speed of 6.3 m/s at an angle of 25\(^\circ\) relative to the magnetic field? \((2.2 \times 10^{-3} \text{ N})\)

**9.7** An ion experiences a magnetic force of \(6.2 \times 10^{-16} \text{ N}\) when moving in the positive \(x\) direction but no magnetic force when moving in the positive \(y\) direction. What is the magnitude of the magnetic force exerted on the ion when it moves in the \(x\)-\(y\) plane along the line \(x = y\)? Assume that the ion’s speed is the same in all cases. \((4.4 \times 10^{-16} \text{ N})\)

**9.8** An electron moving with a speed of \(9.1 \times 10^5 \text{ m/s}\) in the positive \(x\) direction experiences zero magnetic force. When it moves in the positive \(y\) direction, it experiences a force of \(2.0 \times 10^{-15} \text{ N}\) that points in the negative \(z\) direction. What is the direction and magnitude of the magnetic field? \((-1.4 \text{T}, x)\)

**9.9** Two charged particles with different speeds move one at a time through a region of uniform magnetic field. The particles move in the same direction and experience equal magnetic forces. (a) If particle 1 has four times the charge of particle 2, which particle has the greater speed? Explain. (b) Find the ratio of the speeds, \(v_1/v_2\). \((2, \frac{1}{4})\)

**9.10** Find the radius of an electron’s orbit when it moves perpendicular to a magnetic field of 0.45 T with a speed of \(6.27 \times 10^5 \text{ m/s}\). \((7.9 \mu\text{m})\)

**9.11** Find the radius of a proton’s orbit when it moves perpendicular to a magnetic field of 0.45 T with a speed of \(6.27 \times 10^5 \text{ m/s}\). \((1.5 \text{cm})\)

**9.12** An electron accelerated from rest through a voltage of 410 V enters a region of constant magnetic field. If the electron follows a circular path with a radius of 17 cm, what is the magnitude of the magnetic field? \((0.40 \text{mT})\)

**9.13** A 12.5-\(\mu\)C particle with a mass of \(2.80 \times 10^{-5} \text{ kg}\) moves perpendicular to a 1.01-T magnetic field in a circular path of radius 26.8 m. (a) How fast is the particle moving? (b) How long will it take the particle to complete one orbit? \((12.1 \text{m/s}, 13.9 \text{s})\)
9.14 When a charged particle enters a region of uniform magnetic field, it follows a circular path, as indicated in Figure 9.14. (a) Is this particle positively or negatively charged? Explain. (b) Suppose that the magnetic field has a magnitude of 0.180 T, the particle’s speed is $6.0 \times 10^6$ m/s, and the radius of its path is 52.0 cm. Find the mass of the particle, given that its charge has a magnitude of $1.60 \times 10^{-19}$ C. Give your result in atomic mass units, $u$, where $1 \text{u} = 1.67 \times 10^{-27}$ kg. (1.5u)

![Figure 9.14](image)

9.15 A proton with a kinetic energy of $4.9 \times 10^{-16}$ J moves perpendicular to a magnetic field of 0.26 T. What is the radius of its circular path? (3.1cm)

9.16 An alpha particle (the nucleus of a helium atom) consists of two protons and two neutrons, and has a mass of $6.64 \times 10^{-27}$ kg. A horizontal beam of alpha particles is injected with a speed of $1.3 \times 10^5$ m/s into a region with a vertical magnetic field of magnitude 0.155 T. (a) How long does it take for an alpha particle to move halfway through a complete circle? (b) If the speed of the alpha particle is doubled, does the time found in part (a) increase, decrease, or stay the same? Explain. (c) Repeat part (a) for alpha particles with a speed of $2.6 \times 10^5$ m/s. (421ns, 421ns)

9.17 An electron and a proton move in circular orbits in a plane perpendicular to a uniform magnetic field $\vec{B}$. Find the ratio of the radii of their circular orbits when the electron and the proton have (a) the same momentum and (b) the same kinetic energy. (1.0, 0.0233)

9.18 What is the magnetic force exerted on a 2.15-m length of wire carrying a current of 0.695 A perpendicular to a magnetic field of 0.720 T? (1.08N)

9.19 A wire with a current of 2.8 A is at an angle of 36.0° relative to a magnetic field of 0.88 T. Find the force exerted on a 2.25-m length of the wire. (3.3N)

9.20 The magnetic force exerted on a 1.2-m segment of straight wire is 1.6 N. The wire carries a current of 3.0 A in a region with a constant magnetic field of 0.50 T. What is the angle between the wire and the magnetic field? (63°)

9.21 Consider a current loop immersed in a magnetic field, as in Figure 9.21. It is given that $B = 0.34$ T and $I = 9.5$ A. In addition, the loop is a square 0.46 m on a side. Find the magnitude of the magnetic force exerted on each side of the loop. (0, 1.5N)

![Figure 9.21](image)
9.22 A 0.45-m copper rod with a mass of 0.17 kg carries a current of 11 A in the positive \(x\) direction. What are the magnitude and direction of the minimum magnetic field needed to levitate the rod? (-0.34T, \(z\))

9.23 The long, thin wire shown in Figure 9.23 is in a region of constant magnetic field \(\vec{B}\). The wire carries a current of 6.2 A and is oriented at an angle of 7.5° to the direction of the magnetic field. (a) If the magnetic force exerted on this wire per meter is 0.033 N, what is the magnitude of the magnetic field? (b) At what angle will the force exerted on the wire per meter be equal to 0.015 N?

\((41\text{mT}, 3.4°)\)

![Figure 9.23](image)

9.24 A wire with a length of 2.7 m and a mass of 0.75 kg is in a region of space with a magnetic field of 0.84 T. What is the minimum current needed to levitate the wire? (3.2A)

9.25 A high-voltage power line carries a current of 110 A at a location where the Earth’s magnetic field has a magnitude of 0.59 G and points to the north, 72° below the horizontal. Find the direction and magnitude of the magnetic force exerted on a 250-m length of wire if the current in the wire flows (a) horizontally toward the east or (b) horizontally toward the south.

\(\text{(north 18° above horizontal, 1.6N, east, 1.5N)}\)

9.26 A metal bar of mass \(m\) and length \(L\) is suspended from two conducting wires, as shown in Figure 9.26. A uniform magnetic field of magnitude \(B\) points vertically downward. Find the angle \(\theta\) the suspending wires make with the vertical when the bar carries a current \(I\).

\(\text{(tan}^{-1}(\frac{ILB}{mg}))\)

![Figure 9.26](image)