Magnetic Force on Charges & Currents

Magnetism · 8 questions · step-by-step answers at the end

Name: Date: Score: / 8

USEFUL EQUATIONS

$\mathbf{F} = q\mathbf{v} \times \mathbf{B}$ $F = |q|vB\sin\theta$ $r = mv/(|q|B)$ $v = E/B$ $F = ILB\sin\theta$

Questions

Show your working in the space under each question.

1. In a velocity selector, E = 1000 V/m and B = 0.010 T. What speed passes straight through?

2. A proton (m = 1.67×10^{-27} kg) moves at 3.0×10^{5} m/s perpendicular to a 0.050 T field. Find the force on it and the radius of its path.

3. A charge moves parallel to a magnetic field. What force does it feel?

4. A 0.50 m wire carrying 3.0 A makes 30° with a 0.40 T field. What force acts on it?

5. An electron and a proton enter the same field at the same speed. Compare their paths.

6. A semicircular wire of radius R carrying current I lies in a uniform field B perpendicular to its plane. What is the net force on it?

7. A particle's speed doubles in a uniform B. What happens to its radius and period?

8. Why can't a static magnetic field change a charged particle's kinetic energy?

Step-by-step answers

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1. $v = E/B = 1000/0.010 = \mathbf{1.0 \times 10^5\ m/s}$.

2. 1. $F = qvB = (1.6 \times 10^{-19})(3.0 \times 10^5)(0.050) = \mathbf{2.4 \times 10^{-15}\ N}$.
2. The magnetic force provides the centripetal force: $qvB = mv^2/r$.
3. $r = mv/(qB) = (1.67 \times 10^{-27})(3.0 \times 10^5)/[(1.6 \times 10^{-19})(0.050)] = \mathbf{0.063\ m}$ (6.3 cm).
4. An electron at the same speed would curve the other way, on a circle 1836 times smaller.

Answer: $F = 2.4 \times 10^{-15}$ N, r = 6.3 cm

3. **None**: $\sin 0° = 0$.

4. $F = ILB \sin\theta = (3)(0.5)(0.4)(0.5) = \mathbf{0.30\ N}$.

5. They curve in **opposite directions**, and the electron's radius is **1836× smaller** ($r \propto m$).

6. The same as for the straight diameter: **F = 2IRB**.

7. Radius **doubles**; period **unchanged**.

8. $\mathbf{F} \perp \mathbf{v}$ always, so $P = \mathbf{F}\cdot\mathbf{v} = \mathbf{0}$.