B11 · Extra practice, worked solutions

Magnetic force on a moving charge | Diploma-style set of 8

Easy · B11-X01. An electron moves at 2.00×10^{6} m/s at right angles to a magnetic field of 0.0300 T. Use $e = 1.60 \times 10^{-19}$ C. Find the size of the magnetic force on it, in newtons.

1. Givens: $v = 2.00 \times 10^{6}$ m/s; $B = 0.0300$ T; angle 90°; $q = 1.60 \times 10^{-19}$ C. Question: F.

2. $F = qvB \sin\theta$ and $\sin 90° = 1$.

3. $F = (1.60 \times 10^{-19})(2.00 \times 10^{6})(0.0300) = 9.60 \times 10^{-15}$ N.

4. Answer: 9.60×10^{-15} N

Easy · B11-X02. A proton sits at rest in a magnetic field. What is the magnetic force on it?

A. Zero
B. It is along the field.
C. It is at right angles to the field.
D. It depends on the proton’s mass.

1. Givens: the proton is at rest ($v = 0$). Question: the magnetic force.

2. $F = qvB \sin\theta$. With $v = 0$, $F = 0$.

3. A magnetic force needs a moving charge.

4. Answer: A. Zero

Medium · B11-X03. An alpha particle ($q = 3.20 \times 10^{-19}$ C) moves at 5.00×10^{5} m/s at right angles to a field of 0.800 T. Find the size of the magnetic force, in newtons.

1. Givens: $q = 3.20 \times 10^{-19}$ C; $v = 5.00 \times 10^{5}$ m/s; $B = 0.800$ T; angle 90°. Question: F.

2. At right angles, $F = qvB$.

3. $F = (3.20 \times 10^{-19})(5.00 \times 10^{5})(0.800) = 1.28 \times 10^{-13}$ N.

4. Answer: 1.28×10^{-13} N

Medium · B11-X04. A proton moves at 8.00×10^{5} m/s at 30° to a magnetic field of 0.500 T. Use $e = 1.60 \times 10^{-19}$ C. Find the size of the magnetic force, in newtons.

1. Givens: $q = 1.60 \times 10^{-19}$ C; $v = 8.00 \times 10^{5}$ m/s; $B = 0.500$ T; $\theta = 30°$ (between v and B). Question: F.

2. $F = qvB \sin \theta$.

3. $F = (1.60 \times 10^{-19})(8.00 \times 10^{5})(0.500) \sin 30° = 3.20 \times 10^{-14}$ N.

4. Answer: 3.20×10^{-14} N

Medium · B11-X05. Take east, north and up as directions. An electron moves east through a magnetic field that points north. Which way is the magnetic force on the electron?

A. Up
B. Down
C. West
D. South

1. Givens: electron moving east; field north. Question: the force direction.

2. For a positive charge: fingers north (B), thumb east (v). The palm faces up, so the force on a positive charge is up.

3. The electron is negative, so reverse it: the force is down.

4. Answer: B. Down

Challenging · B11-X06. An electron moving at 4.00×10^{6} m/s at right angles to a magnetic field feels a force of 1.92×10^{-13} N. Use $e = 1.60 \times 10^{-19}$ C. Find the size of the field in tesla.

1. Givens: $v = 4.00 \times 10^{6}$ m/s; $F = 1.92 \times 10^{-13}$ N; angle 90°; $q = 1.60 \times 10^{-19}$ C. Question: B.

2. $F = qvB$, so $B = F \div (qv)$.

3. $B = 1.92 \times 10^{-13} \div ((1.60 \times 10^{-19})(4.00 \times 10^{6})) = 0.300$ T.

4. Answer: 0.300 T

Challenging · B11-X07. A proton moves at right angles to a field of 0.400 T and feels a force of 6.40×10^{-15} N. Use e = 1.60×10^{-19} C. Find the speed of the proton in m/s.

1. Givens: B = 0.400 T; F = 6.40×10^{-15} N; angle 90°; q = 1.60×10^{-19} C. Question: v.

2. F = qvB, so v = F ÷ (qB).

3. v = $6.40 \times 10^{-15} \div ((1.60 \times 10^{-19})(0.400)) = 1.00 \times 10^{5}$ m/s.

4. Answer: 1.00×10^{5} m/s

Challenging · B11-X08. A charged particle moves through a magnetic field at constant speed in a circle. Explain why the magnetic force does not change the particle’s speed.

1. Givens: a charge moving in a magnetic field, speed constant. Question: why the force does not change the speed.

2. The magnetic force is always at right angles to the velocity.

3. A force at right angles has no part along the motion, so it does no work and cannot change the kinetic energy or the speed.

4. It only changes the direction of the velocity, which is why the path curves.