

Magnetic fields of wires and forces on moving charges

AP Physics 2 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems cover the AP Physics 2 magnetism unit: the field of a long wire, the force on a moving charge, circular motion in a field, the force on a current-carrying wire and the forces between parallel wires. They begin with single formulas and finish with multi-step designs. They suit AP students and anyone studying A Level or IB magnetism. Draw a diagram first, then apply the right-hand rule and write each unit.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 12

Problem 1 Field of a cable (easy)

A cable carries 10 A.

1. Calculate the magnetic field 2.0 cm from the cable.
2. State how the field changes when the distance is doubled.

Problem 2 Field direction (easy)

A long straight wire carries current out of the page.

1. State the direction of the field lines around it.
2. State the right-hand rule that gives this direction.

Problem 3 Force on a proton (easy)

A proton ($q = 1.6 \times 10^{-19}$ C) moves at 3.0×10^5 m/s at right angles to a field of 0.20 T.

1. Calculate the magnetic force.
2. State what happens to the speed of the proton.

Problem 4 Force on a wire (easy)

A 0.25 m wire carries 4.0 A at right angles to a field of 0.50 T.

1. Calculate the force on the wire.
2. Calculate the force if the current is doubled.

Problem 5 When is the force zero? (easy)

State three situations in which a magnetic field exerts no force on a particle.

Problem 6 Which way? (easy)

A positive charge moves to the right in a field directed into the page.

1. State the direction of the force.
2. State the direction for an electron with the same velocity.

Problem 7 Unit conversions (easy)

Aarav in Pune records two fields.

1. Convert 250 mT to tesla.
2. Convert 45 μT to tesla.
3. Write 1 T in terms of N, A and m.

Problem 8 Matching the Earth's field (medium)

A wire carries 30 A. Calculate the distance from the wire at which its field equals the Earth's field of $5.0 \times 10^{-5} \text{ T}$.

Problem 9 Proton in a field (medium)

A proton (mass $1.67 \times 10^{-27} \text{ kg}$) moves at $4.0 \times 10^5 \text{ m/s}$ perpendicular to a field of 0.50 T.

1. Calculate the radius of its path.
2. Calculate the time for one complete circle.

Problem 10 Wire at an angle (medium)

A 0.60 m wire carrying 8.0 A makes an angle of 30° with a field of 0.25 T.

1. Calculate the force on the wire.
2. State the angle that would give the greatest force.

Problem 11 Velocity selector (medium)

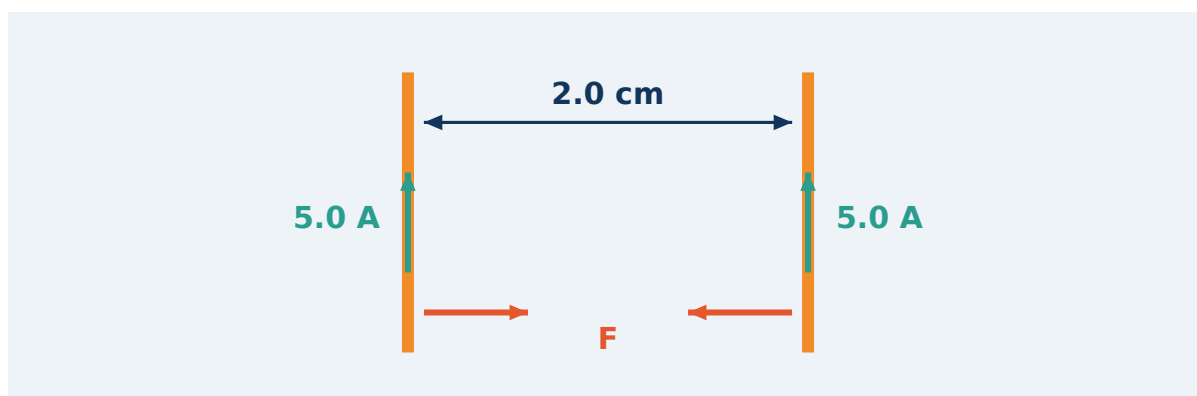
Charged particles pass undeflected through crossed fields: an electric field of $4.0 \times 10^3 \text{ V/m}$ and a magnetic field of 0.020 T.

1. Write the condition for no deflection.
2. Calculate the speed of the undeflected particles.

Problem 12 Two parallel wires (medium)

Two wires 2.0 cm apart each carry 5.0 A in the same direction.

1. Calculate the force per metre.
2. State whether the wires attract or repel.



Two parallel currents.

Problem 13 Radius and field data (medium)

Kofi in Accra fires electrons at the same speed into different fields.

Field B (mT): 1.0, 2.0, 4.0

Radius r (mm): 11.4, 5.7, 2.85

1. Describe the relationship between r and B.
2. Calculate $r \times B$ for each row.
3. Use the result to find the speed of the electrons ($m = 9.11 \times 10^{-31}$ kg).

Problem 14 Accelerating a bar (medium)

A 0.15 m metal bar of mass 0.050 kg carries 12 A at right angles to a field of 0.40 T. Friction is negligible.

1. Calculate the magnetic force.
2. Calculate the acceleration of the bar.

Problem 15 Electron versus proton (medium)

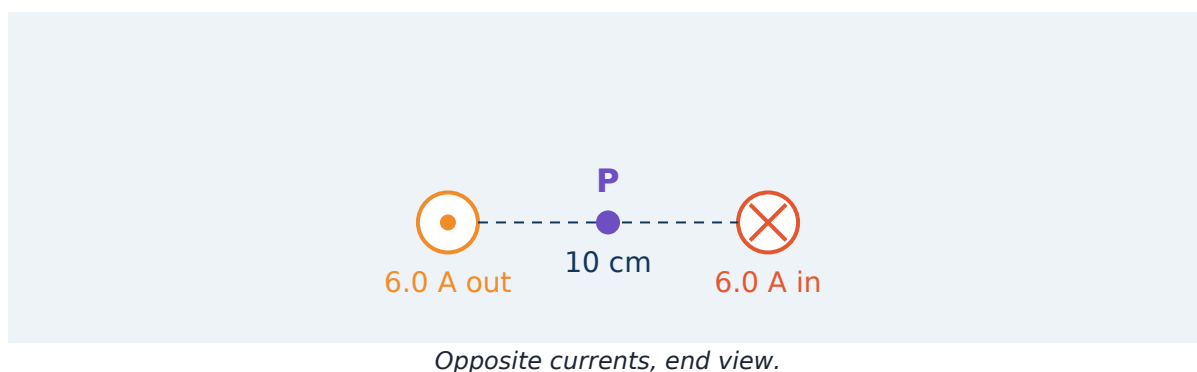
An electron and a proton enter the same uniform field at the same speed, perpendicular to the field.

1. State the ratio of the radius of the proton path to that of the electron path.
2. State how their directions of circulation compare.

Problem 16 Field between two wires (hard)

Two long parallel wires 10 cm apart carry 6.0 A each. P is the midpoint, 5.0 cm from each wire.

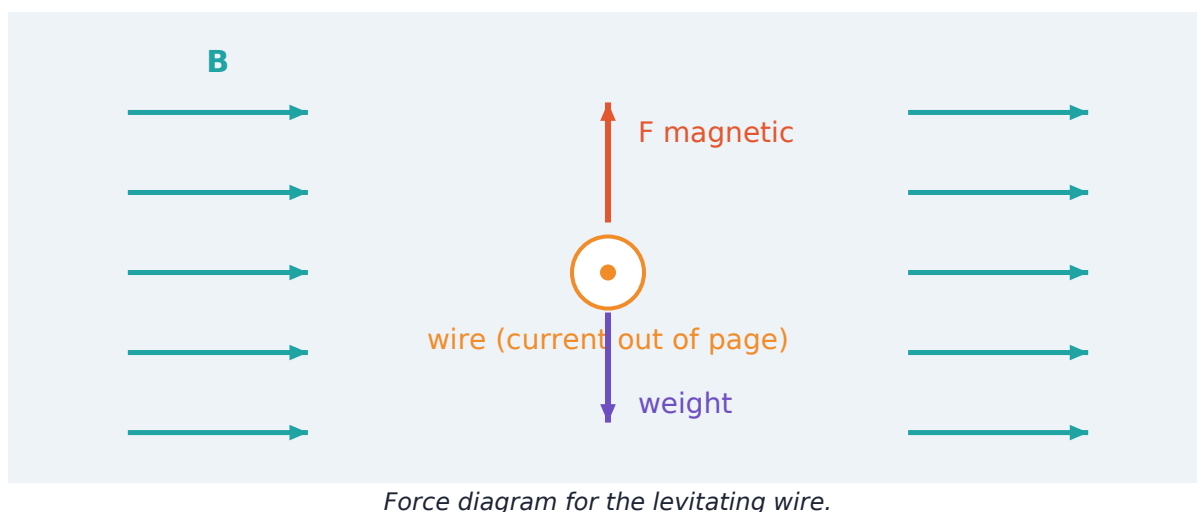
1. Calculate the field at P when the currents are in opposite directions.
2. State the field at P when the currents are in the same direction.



Problem 17 Levitating a wire (hard)

A horizontal wire 0.50 m long has a mass of 12 g. It is in a horizontal field of 0.060 T perpendicular to the wire. Use $g = 9.81 \text{ N/kg}$.

1. Calculate the current needed for the magnetic force to balance the weight.
2. State the direction of the current if B points to the right in the diagram.



Problem 18 Mass spectrometer (hard)

Singly charged ions of mass $6.5 \times 10^{-26} \text{ kg}$ are accelerated from rest through 500 V and enter a field of 0.100 T at right angles.

1. Calculate the speed of the ions.
2. Calculate the radius of their path.

Problem 19 Spiral path (hard)

A proton enters a uniform field of 0.30 T at 60° to the field with speed $5.0 \times 10^5 \text{ m/s}$.

1. Calculate the magnetic force on the proton.
2. Calculate the radius of the circular part of its motion.
3. Calculate the distance it advances along the field in one turn.

Problem 20 Spot the errors (hard)

A student writes: (i) "A magnetic field makes a charge speed up because it exerts a force on it." (ii) "A wire parallel to the field feels the largest force."

1. Explain the mistake in (i).
2. Explain the mistake in (ii) and calculate the force on a 0.50 m wire carrying 3.0 A at 0° to a field of 0.20 T.