

AP Physics C: E&M Formula and Strategy Guide

Calculus-based electricity and magnetism: electrostatics, conductors and capacitors, DC circuits, magnetic fields, and electromagnetic induction. Work a section, then try the matching questions in the practice worksheet.

SECTIONS	5	WORKED EXAMPLES	2	FORMAT	Print friendly
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How to use this guide

A formula you cannot place is not knowledge yet. Work the recall drill below before the questions.

- Draw the field or circuit before writing an equation — direction and geometry drive almost every E&M problem.
- Track signs carefully: charge sign, current direction, and field direction all matter.
- Gauss's law and Ampere's law only simplify a problem when the symmetry matches; recognize the symmetry first.

1. Electrostatics

NAME	FORMULA	WHEN TO USE
Coulomb's law	$F = k q_1 q_2 / r^2$	Force between two point charges.
Electric field (point charge)	$E = k q / r^2$	Field due to a single point charge.
Electric field (from force)	$E = F/q$	Field experienced by a test charge.
Electric potential (point charge)	$V = k q / r$	Potential energy per unit charge near a point charge.
Gauss's law	$\text{flux} = Q_{\text{enclosed}} / \epsilon_0$	Finding the field of a symmetric charge distribution.

WORKED EXAMPLE

Find the electric field 2 m from a $+5 \times 10^{-6} \text{ C}$ point charge. ($k = 9 \times 10^9$)

1. $E = kq/r^2$
2. $E = (9 \times 10^9)(5 \times 10^{-6})/(2^2)$
3. $E = 45000/4 = 11250 \text{ N/C}$

Check: Field strength decreases with the square of distance, as expected.

2. Conductors, capacitors, and dielectrics

NAME	FORMULA	WHEN TO USE
Capacitance	$C = Q/V$	Relating stored charge to voltage across a capacitor.
Parallel plate capacitor	$C = \epsilon_0 A / d$	Capacitance from geometry.
Energy stored in a capacitor	$U = 1/2 C V^2$	Energy stored in an electric field.
Dielectric effect	inserting a dielectric increases capacitance by factor κ	Explaining why a dielectric-filled capacitor stores more charge.
Conductors in equilibrium	E field inside is zero, excess charge resides on the surface	Explaining electrostatic shielding.

3. DC circuits

NAME	FORMULA	WHEN TO USE
Ohm's law	$V = IR$	Relating voltage, current, and resistance.
Series resistors	$R_{eq} = R_1 + R_2 + \dots$	Resistors in a single loop.
Parallel resistors	$1/R_{eq} = 1/R_1 + 1/R_2 + \dots$	Resistors across shared nodes.
Kirchhoff's voltage law	sum of voltage changes around a loop = 0	Analyzing a multi-loop circuit.
Kirchhoff's current law	current in = current out at a junction	Conservation of charge at a node.
RC circuit charging	$V(t) = V_0(1 - e^{-t/RC})$	Describing capacitor voltage over time while charging.

4. Magnetic fields and forces

NAME	FORMULA	WHEN TO USE
Magnetic force on a charge	$F = qvB \sin(\theta)$	Force on a moving charge in a magnetic field.
Magnetic force on a wire	$F = BIL \sin(\theta)$	Force on a current-carrying wire in a field.
Field from a long straight wire	$B = \mu_0 I / (2\pi r)$	Finding the field created by a current.
Ampere's law	line integral of $B = \mu_0 I_{enclosed}$	Finding the field of a symmetric current distribution.

WORKED EXAMPLE

A proton moves at 2×10^6 m/s perpendicular to a 0.5 T field. Find the magnetic force ($q = 1.6 \times 10^{-19}$ C).

1. $F = qvB \sin(90)$
2. $F = (1.6 \times 10^{-19})(2 \times 10^6)(0.5)(1)$
3. $F = 1.6 \times 10^{-13}$ N

Check: Perpendicular velocity and field give the maximum possible force.

5. Electromagnetic induction

NAME	FORMULA	WHEN TO USE
Magnetic flux	$\phi = B A \cos(\theta)$	The amount of field passing through a loop.
Faraday's law	$\text{EMF} = -d(\phi)/dt$	The induced EMF from a changing magnetic flux.
Lenz's law	induced current opposes the change in flux	Determining the direction of an induced current.
Inductor	$V = L dI/dt$	Relating induced voltage to changing current.

Notes and tutor hand-off

Bring this page to your next session so the tutor can start from what actually blocked you.

Which unit needs another pass: electrostatics, circuits, magnetism, or induction?

One sign convention (charge, current direction, field direction) you keep mixing up:

Worksheet question numbers to review with a tutor:
