

# FREE AP PHYSICS C: E&M

## FORMULA SHEET

*All the Essential Formulas You Need for Test Day*

### Unit 1: Electrostatics

- Coulomb's Law:  $\mathbf{F} = k (\mathbf{q}_1 \mathbf{q}_2) / r^2$
- Electric Field (point charge):  $\mathbf{E} = k \mathbf{q} / r^2$
- Electric Force:  $\mathbf{F} = q \mathbf{E}$
- Electric Potential (point charge):  $V = k q / r$
- Potential Energy (two charges):  $U = k (\mathbf{q}_1 \mathbf{q}_2) / r$
- Relationship between field and potential:  
 $\mathbf{E} = -\Delta V / \Delta x$
- Gauss's Law:  $\oint \mathbf{E} \cdot d\mathbf{A} = Q_{\text{enclosed}} / \epsilon_0$

### Unit 2: Conductors, Capacitors, Dielectrics

- Capacitance:  $C = Q / V$
- Parallel-Plate Capacitor:  $C = \epsilon_0 A / d$
- Energy in a Capacitor:  $U = \frac{1}{2} C V^2$
- Equivalent Capacitance (series):  
 $1 / C_{\text{eq}} = 1 / C_1 + 1 / C_2 + \dots$
- Equivalent Capacitance (parallel):  
 $C_{\text{eq}} = C_1 + C_2 + \dots$

### Unit 3: Work, Energy, and Power

- Ohm's Law:  $V = IR$
- Electric Power:  $P = IV = I^2 R = V^2 / R$
- Resistors in Series:  $R_{\text{eq}} = R_1 + R_2 + \dots$
- Resistors in Parallel:  $1 / R_{\text{eq}} = 1 / R_1 + 1 / R_2 + \dots$
- Current:  $I = \Delta Q / \Delta t$
- Kirchhoff's Rules:  
Junction Rule:  $\Sigma I_{\text{in}} = \Sigma I_{\text{out}}$   
Loop Rule:  $\Sigma \Delta V = 0$

### Constants

- $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2 / (\text{N} \cdot \text{m}^2)$
- $\mu_0 = 4\pi \times 10^{-7} \text{ T} \cdot \text{m} / \text{A}$
- $k = 1 / (4\pi\epsilon_0) \approx 9.0 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$
- $e = 1.60 \times 10^{-19} \text{ C}$
- $c = 3.0 \times 10^8 \text{ m/s}$
- $h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$

### Unit 4: Magnetic Fields

- Magnetic Force on a Charge:  $\mathbf{F} = q \mathbf{v} \mathbf{B} \sin\theta$
- Magnetic Force on a Wire:  $\mathbf{F} = I \mathbf{L} \mathbf{B} \sin\theta$
- Torque on a Current Loop:  $\tau = I A B \sin\theta$
- Magnetic Field of a Long Straight Wire:  
 $B = \mu_0 I / (2\pi r)$
- Biot-Savart Law:  $\mathbf{B} = (\mu_0 / 4\pi) \int (I d\mathbf{l} \times \hat{\mathbf{r}}) / r^2$
- Ampère's Law:  $\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{\text{enclosed}}$

### Unit 5: Electromagnetism & Induction

- Magnetic Flux:  $\Phi_B = B A \cos\theta$
- Faraday's Law:  $\epsilon = -d\Phi_B / dt$
- Lenz's Law: **Direction of induced current opposes flux change**
- Inductance:  $\epsilon = -L (dI/dt)$
- Energy in an Inductor:  $U = \frac{1}{2} L I^2$

### Unit 6: Maxwell's Equations (Integral Form)

- Rotational kinetic energy:  $KE_{\text{rot}} = \frac{1}{2} I \omega^2$
- Total kinetic energy (rolling):  
 $KE_{\text{total}} = \frac{1}{2} M v^2 + \frac{1}{2} I \omega^2$
- Angular momentum:  
 $\mathbf{L} = \mathbf{r} \times \mathbf{p}$  (particle),  $L = I \omega$  (rigid body)
- Conservation of angular momentum:  
 $L_{\text{initial}} = L_{\text{final}}$

**Tip:** AP Physics C: E&M questions test how formulas connect, not just memorization. Practice linking electric and magnetic concepts

**Need help mastering these formulas?**

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