

Electrostatics — Complete Formula Card

- The chapter's map: charge → field → potential → Gauss → conductors → capacitors → dielectrics
- Energy methods often beat force methods — look for the $\frac{1}{2}$'s
- The connected/isolated capacitor split decides every capacitor question

What	Formula	Remember
Coulomb's law	$F = kq_1q_2/r^2$	$k = 9 \times 10^9$; like repels
Field (point charge)	$E = kQ/r^2$; $E = F/q$	N/C; vector
Potential (point charge)	$V = kQ/r$; $U = qV$	SCALAR — plain addition
Field–potential link	$E = -dV/dr$	field = slope of V
Gauss's law	$\Phi = q_{\text{enc}}/\epsilon_0$	shape-free; symmetry needed to use
Charged shell	$E = 0$ inside; kQ/r^2 outside	point-like outside
Sheet / line	$E = \sigma/2\epsilon_0$; $E = \lambda/2\pi\epsilon_0 r$	constant; $1/r$
Conductors	$E = 0$ inside; charge on surface	Faraday cage blocks outside-in
Capacitance	$C = Q/V$; plates: $\epsilon_0 A/d$	farad = C/V
Dielectric	$C = \kappa\epsilon_0 A/d$	water ~ 80 , glass ~ 7
Combinations	parallel: add; series: reciprocals	swapped vs resistors
Capacitor energy	$U = \frac{1}{2}CV^2 = \frac{1}{2}QV$	the half is real
Energy density	$u = \frac{1}{2}\epsilon_0 E^2$	energy lives in the field
Locked quantities	connected: V fixed; isolated: Q fixed	decide first, compute after

Mistakes to avoid

- Vector/scalar mixing: fields add as arrows, potentials as plain numbers
- The $\frac{1}{2}$ dropped under time pressure: QV is the work spent, $\frac{1}{2}QV$ is what stayed stored
- Locked-quantity amnesia: connected → V fixed; isolated → Q fixed. Decide BEFORE computing
- Units drift in multi-step problems: convert mm, μC , kV at the START of every step