CHARGES DAY 9: UNIT REVIEW

BIG IDEAS TO REMEMBER

- **Coulomb:** $F = kq_1q_2/r^2$, third-law pairs, superposition adds vectors. μC regime: $k(\mu C)^2 = 9\times10^{-3}$.
- **Field:** $E = F/q$ exists without a probe; point charge kq/r^2; once E is known, $F = qE$ gives the force (negatives feel it backwards).
- **dq integration:** rod on axis $k\lambda(1/a - 1/(a+L))$; ring $kQz/(z^2+R^2)^{3/2}$; disk $2\pi k\sigma[1 - z/\sqrt{z^2+R^2}]$. EVERY result must pass the far-away kQ/r^2 check.
- **Gauss:** $\Phi = q_{enc}/\varepsilon_0$ always; useful when symmetry lets $\Phi = E\cdot A$. Shell: kQ/r^2 out, 0 in; solid: kQr/R^3 in; line $2k\lambda/r$; sheet $2\pi k\sigma$.
- **Conductors:** $E = 0$ inside; charge lives on the surfaces; inner surface = –(enclosed charge); $E \perp$ surface at σ/ε_0; cavities shielded.

A Method Choice

For each, name the tool (Coulomb / field superposition / dq integral / Gauss / conductor facts): **(a)** E outside a uniformly charged sphere; **(b)** E on the axis of a short rod; **(c)** force between two point charges; **(d)** charge on a shell's inner surface.

MIXED PRACTICE

B Superposition Chain

+3.0 μC at x = 0, −1.0 μC at x = 2.0 m. **(a)** Net E at x = 1.0 m (between them). **(b)** Force there on a +2.0 μC charge.

C Integral vs Gauss

A wire carries λ = 2.0 μC/m. **(a)** E at r = 0.5 m via $2k\lambda/r$. **(b)** State in one sentence why Gauss beat the Day-3 integral here — and name the symmetry that made it legal.

D The r^2 Cancellation, Explained

A +5.0 μC charge is wrapped in spheres of radius 1.0 m and 2.0 m. Compute the flux through each, then write ONE sentence on what physical feature of $1/r^2$ fields makes them equal.

AP-STYLE PRACTICE

E Short FRQ: The Charged Sphere Family

A uniformly charged INSULATING sphere has radius R and total charge +Q.

a. **Derive** E(r) for $r < R$ using Gauss's law — show the linear growth.

b. **Sketch** E(r) from 0 to 3R, labeling the surface value kQ/R^2.

c. **Argue:** if the sphere were CONDUCTING instead, how would the graph change, and why?

F Reflection

Which of these can you least reliably do on your own — dq integrals, Gauss's law, or the conductor facts? Name it, and write your plan to fix it before the test:

Test Reminder: convert $\mu C \to C$ before computing; check limits on every integral; state q_{enc} explicitly before using Gauss; and remember the inner-surface total is $-q_{enclosed}$ no matter where the charge sits.