CIRCUITS DAY 7: UNIT REVIEW

BIG IDEAS TO REMEMBER

- **$I = dq/dt$**, $Q = \int I\,dt$; $R = \rho L/A$; **$V = IR$**.
- **$P = IV = I^2R = V^2/R$**; $E = \int P\,dt$; the kWh is 3.6×10^6 J.
- **Series adds R** (same I); **parallel adds 1/R** (same V) — capacitors flipped.
- **Kirchhoff:** junctions conserve charge; loops close because potential is single-valued. Real battery: $I = \varepsilon/(R+r)$, $V_{term} = \varepsilon - Ir$.
- **RC:** $\tau = RC$; discharge $Q_0 e^{-t/\tau}$, charge $C\varepsilon(1 - e^{-t/\tau})$; 63% at τ, 99.3% at 5τ.

A Rules Rapid-Fire

One-line answers: **(a)** Two identical resistors: series R_{eq} vs parallel R_{eq} — ratio? **(b)** Why does the SMALLER parallel branch carry MORE current? **(c)** At $t = 0$, a charging capacitor acts like what circuit element? At $t \gg \tau$? **(d)** What does a voltmeter read across an ideal battery delivering current — and a real one?

MIXED PRACTICE

B Network Chain

A 24 V battery drives a 6.0 Ω resistor in series with (3.0 Ω ∥ 6.0 Ω). Find R_eq, the battery current, the voltage across the parallel pair, the current in each branch, and the power in the series resistor.

C Real-Battery Chain

ε = 12 V, r = 0.5 Ω, load R = 5.5 Ω. Find I, V_term, the power to the load, the power wasted in the battery, and the efficiency R/(R+r).

D RC Chain

C = 2.0 μF at 12 V discharges through R = 1.0 MΩ. Find τ, I_0, the charge remaining at t = 2.0 s, and the time for the charge to halve.

AP-STYLE PRACTICE

E Short FRQ: Derive the Discharge

A capacitor C charged to Q_0 discharges through R.

a. **Write** the loop rule and convert it to a differential equation in q(t).

b. **Solve** it by separation of variables, applying the initial condition.

c. **Show** that the total energy dissipated in R equals the capacitor's initial $\frac{1}{2}Q_0^2/C$ (energy argument, no integral required).

F Reflection

Which of these can you least reliably do on your own — network collapse, Kirchhoff bookkeeping, real batteries, or RC exponentials? Name it, and write your plan to fix it before the test:

Test Reminder: resistor rules are the capacitor rules FLIPPED; the loop rule needs consistent signs (pick a direction and commit); $\tau = RC$ comes out in seconds when R is in Ω and C in F — or in seconds when MΩ meets μF.