

Kirchhoff's rules and RC transients

AP Physics C (Mechanics and E&M, calculus-based) · Lab answers

The answers use the sample values. Your own τ will depend on your actual capacitor, which can differ from its label by a large margin, but the log graph should still be a straight line and τ/R should land within the tolerance of the component.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:E&M Unit 11

Question 1 Plot $\ln V$ against t

$V = V_0 e^{-t/\tau}$, so $\ln V = \ln V_0 - t/\tau$. The points lie on a **straight line of negative gradient**.

Question 2 Gradient

Gradient = $(-1.35 - 1.79)/(60 - 0) = -3.14/60 = \mathbf{-0.052 \text{ s}^{-1}}$.

Question 3 Time constant

$\tau = -1/\text{gradient} = 1/0.0523 = \mathbf{19 \text{ s}}$.

Question 4 Capacitance

$C = \tau/R = 19.1/22\,000 = 8.7 \times 10^{-4} \text{ F}$, so **870 μF** , which is 13 % below the nominal value and within the usual 20 % tolerance of electrolytic capacitors.

Question 5 Half-time check

$t_{1/2} = \tau \ln 2 = 19.1 \times 0.693 = \mathbf{13 \text{ s}}$. The table shows $V = 3.5 \text{ V}$ at 10 s and 2.1 V at 20 s, so 3.0 V occurs between them, near 13 s, in agreement.

Question 6 Uncertainty

A 0.5 s timing error on 60 s is 0.8 %, but the small readings at 50–60 s have voltage uncertainty 0.01 V on 0.26 V, about 4 %, which affects the log slope most. Overall **$\tau = 19 \pm 1 \text{ s}$** .

Question 7 Reducing error

Using a larger starting voltage and stopping at about 2τ avoids the noisy low readings, and recording with a video of the meter reduces reaction-time error. Both give a **more reliable**

gradient.