

Kirchhoff's rules and RC transients

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

Name: _____ Date: _____ Class: _____ Mark: ____ / 20

This test lasts 45 minutes and is marked out of 20. Show all steps, give answers with units, and use full sentences for explanations. Take $e^{-1} = 0.368$ and $e^{-2} = 0.135$ where useful. You may use a calculator.

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

Time: 45 minutes · 8 questions · Total: 20 marks · Calculator allowed

Question 1 Kirchhoff's rules (2 marks)

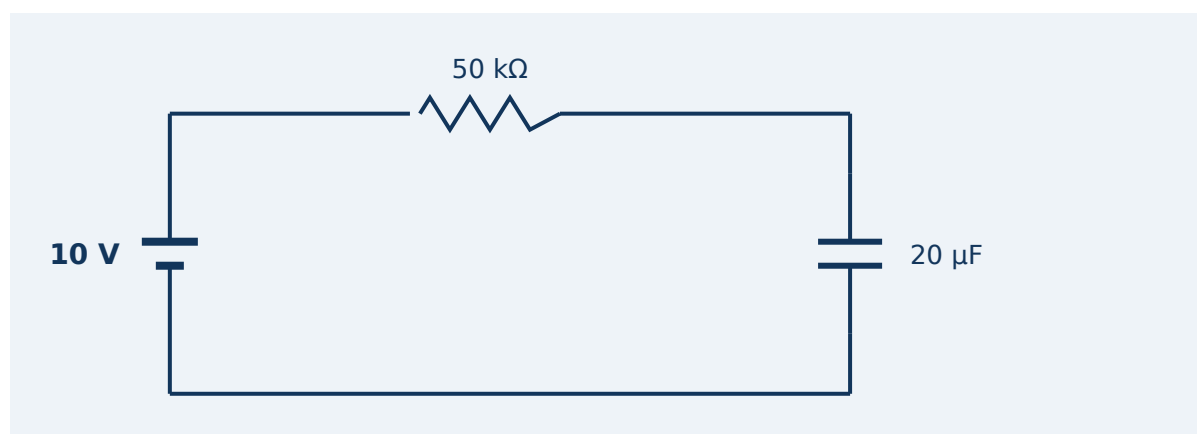
State the physical principle behind (a) the junction rule and (b) the loop rule.

Question 2 Battery and load (2 marks)

A battery of emf 15 V and internal resistance $1.0 \, \Omega$ is connected to a $4.0 \, \Omega$ resistor. Calculate the current and the terminal voltage.

Question 3 Charging a capacitor (3 marks)

The switch in the circuit is closed at $t = 0$ with the capacitor uncharged.



Series RC circuit.

Calculate (a) the time constant, (b) the capacitor voltage at $t = 2.0 \, \text{s}$ and (c) the current at $t = 2.0 \, \text{s}$.

Question 4 Discharge time (3 marks)

A $470\ \mu\text{F}$ capacitor charged to $12\ \text{V}$ discharges through $1.0\ \text{k}\Omega$. Calculate how long the voltage takes to fall to $4.0\ \text{V}$.

Question 5 Limits in time (2 marks)

Explain how an uncharged capacitor behaves immediately after the switch is closed and after a very long time.

Question 6 Derive the equation (3 marks)

Use the loop rule for a charging RC circuit to write a differential equation for $q(t)$, and show that $q = C\epsilon(1 - e^{-t/RC})$ satisfies it.

Question 7 Energy balance (3 marks)

A $100\ \mu\text{F}$ capacitor is charged to $6.0\ \text{V}$ through a resistor from a $6.0\ \text{V}$ battery. Calculate the energy supplied by the battery, stored in the capacitor and dissipated in the resistor.

Question 8 Sketching the current (2 marks)

Sketch the current against time for a discharging capacitor and mark τ on the sketch.