

Resistance, Kirchhoff's rules and steady-state RC circuits

AP Physics 2 (algebra-based) · Worksheet

Name: _____ Date: _____ Class: _____

These 20 problems train the skills of the AP Physics 2 DC circuits unit: using resistivity, reducing series and parallel networks, applying Kirchhoff's rules and reasoning about capacitors in steady state. They move from one-step recall to multi-step analysis.

They suit AP students and anyone studying A Level or university-prep circuits. Show every substitution and write units with each answer.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 11

Problem 1 Lamp resistance (easy)

Chiamaka in Lagos measures 4.5 V across a lamp when the current is 0.30 A.

1. Calculate the resistance of the lamp.
2. Calculate the power dissipated in the lamp.

Problem 2 Wire dimensions (easy)

A technician compares two wires made of the same metal.

1. State the SI unit of resistivity.
2. State how the resistance changes when the length is doubled.
3. State how the resistance changes when the diameter is doubled.

Problem 3 Three in series (easy)

Bilal in Lahore connects resistors of 10 Ω , 22 Ω and 33 Ω in series across a 13 V supply.

1. Calculate the equivalent resistance.
2. Calculate the current in the circuit.

Problem 4 Two in parallel (easy)

A 20 Ω resistor and a 30 Ω resistor are connected in parallel across a 6.0 V battery.

1. Calculate the equivalent resistance.
2. Calculate the current drawn from the battery.

Problem 5 Heating element (easy)

A nichrome wire has resistivity $1.1 \times 10^{-6} \Omega \cdot \text{m}$, length 2.0 m and cross-sectional area 0.20

mm².

1. Convert the area to m².
2. Calculate the resistance of the wire.
3. Calculate the current when 5.5 V is applied.

Problem 6 Junction currents (easy)

At a junction, currents of 3.0 A and 2.0 A flow in. One wire carries 1.2 A out.

1. Calculate the current in the only other wire leaving the junction.
2. Name the conservation law behind the junction rule.

Problem 7 Long wait (easy)

Kofi in Accra connects a capacitor, a resistor and a battery in series and waits for a long time.

1. State the current in the circuit.
2. State the voltage across the resistor.
3. State the voltage across the capacitor.

Problem 8 Charge and energy (medium)

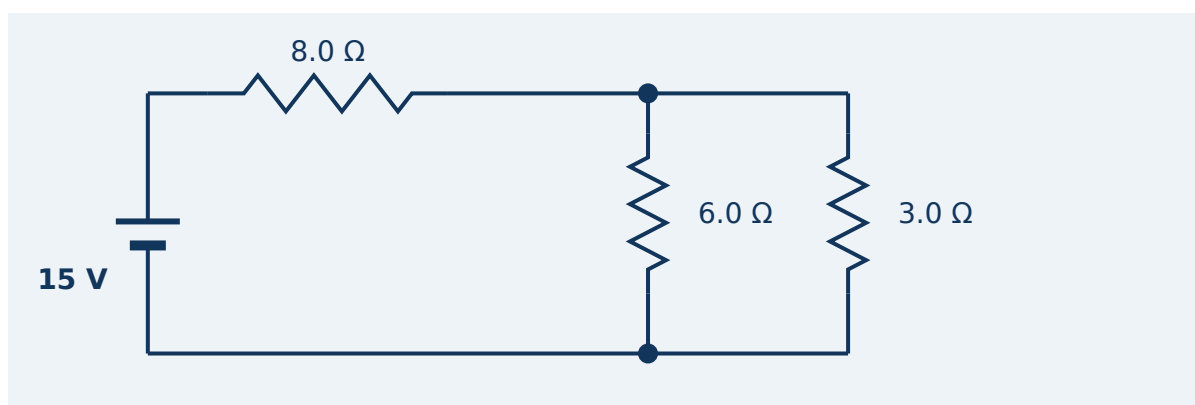
A 220 μF capacitor is charged to 9.0 V.

1. Calculate the charge stored.
2. Calculate the energy stored using $U = \frac{1}{2}CV^2$.

Problem 9 Series-parallel network (medium)

A 15 V battery is connected to an 8.0 Ω resistor in series with a 6.0 Ω and a 3.0 Ω resistor in parallel.

1. Calculate the equivalent resistance.
2. Calculate the battery current.
3. Calculate the current in the 6.0 Ω resistor.



Circuit for this problem.

Problem 10 Series or parallel lamps (medium)

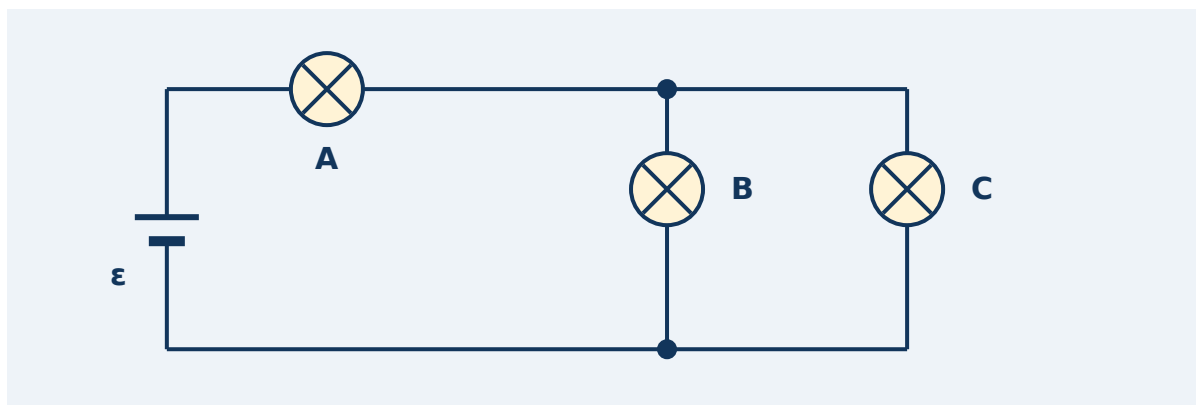
Two identical lamps of resistance $12\ \Omega$ are connected to a $6.0\ \text{V}$ battery of negligible internal resistance.

1. Calculate the total power when the lamps are in series.
2. Calculate the total power when the lamps are in parallel.
3. State which arrangement gives brighter lamps.

Problem 11 Three bulbs (medium)

Three identical bulbs A, B and C are connected as shown: A in series with the parallel pair B and C, across an ideal battery.

1. Rank the bulbs by brightness and explain.
2. Bulb C is removed. State what happens to the brightness of A and of B, with reasons.



Circuit for this problem.

Problem 12 Length and resistance data (medium)

Mei in Singapore measures a constantan wire of cross-sectional area $8.0 \times 10^{-8}\ \text{m}^2$.

Length (m): 0.20, 0.40, 0.60, 0.80

Resistance (Ω): 1.22, 2.44, 3.65, 4.87

1. Calculate R/L for the last data pair.
2. Use it to find the resistivity of constantan.

Problem 13 Aluminium cable (medium)

A cable of aluminium ($\rho = 2.8 \times 10^{-8}\ \Omega\cdot\text{m}$) is 120 m long and has diameter 0.45 mm.

1. Calculate the cross-sectional area.
2. Calculate the resistance.
3. Calculate the current when 12 V is applied.

Problem 14 Battery with internal resistance (medium)

A battery of emf $9.0\ \text{V}$ and internal resistance $0.50\ \Omega$ is connected to a $4.0\ \Omega$ resistor.

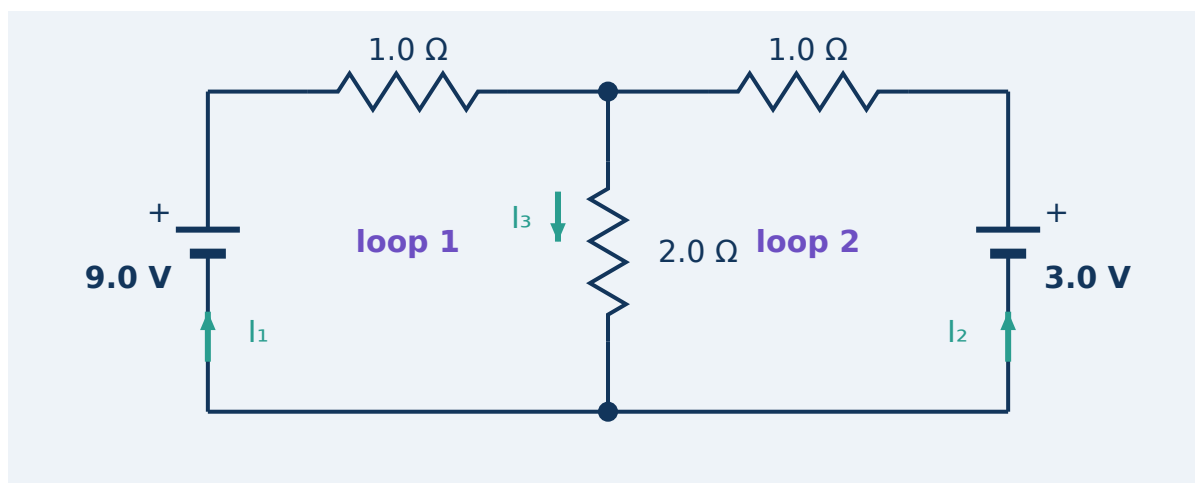
1. Calculate the current.

2. Calculate the terminal voltage.
3. Calculate the power dissipated inside the battery.

Problem 15 Two batteries (medium)

Use the two-loop circuit with $\varepsilon_1 = 9.0 \text{ V}$, $\varepsilon_2 = 3.0 \text{ V}$, $R_1 = 1.0 \Omega$, $R_2 = 1.0 \Omega$ and $R_3 = 2.0 \Omega$.

1. Write the junction equation.
2. Write the two loop equations.
3. Solve for I_1 , I_2 and I_3 and explain any negative sign.



Currents I_1 , I_2 and I_3 are chosen as drawn.

Problem 16 Designing a heater coil (hard)

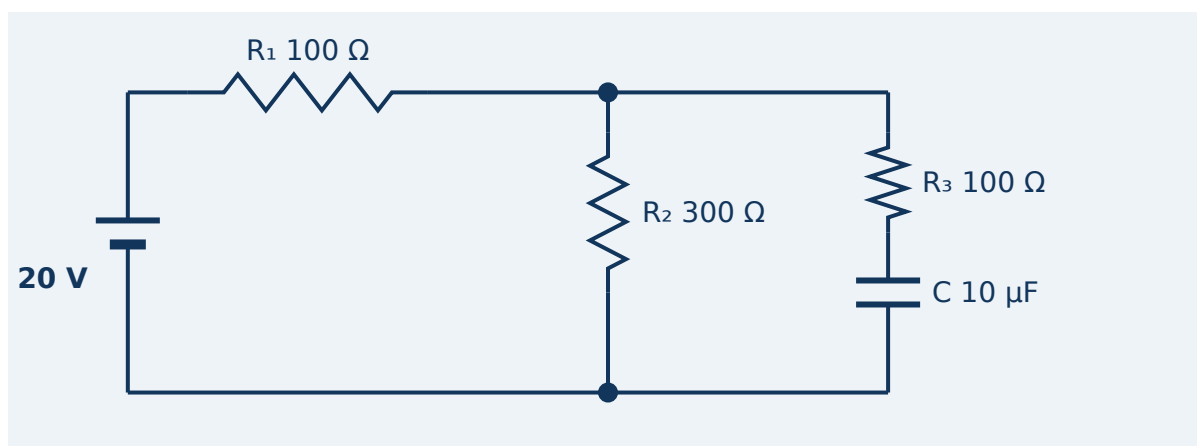
A heater needs a resistance of 24Ω . It uses nichrome wire ($\rho = 1.1 \times 10^{-6} \Omega \cdot \text{m}$) of diameter 0.40 mm .

1. Calculate the cross-sectional area.
2. Calculate the length of wire needed.
3. Calculate the power when connected to 240 V .

Problem 17 Capacitor in a network (hard)

A 20 V battery is connected to $R_1 = 100 \Omega$ in series with a parallel pair: $R_2 = 300 \Omega$, and a branch containing $R_3 = 100 \Omega$ in series with an uncharged $C = 10 \mu\text{F}$.

1. Calculate the battery current just after the circuit is closed.
2. Calculate the current in R_3 at that instant.
3. After a long time, calculate the charge on the capacitor.



Circuit for this problem.

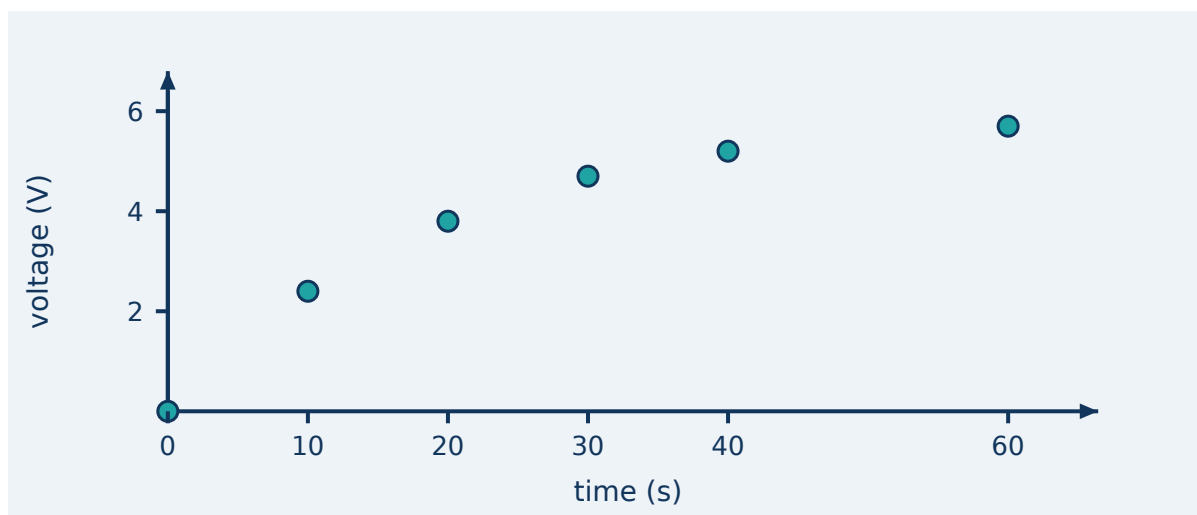
Problem 18 Reading a charging graph (hard)

Diego in Texas charges a $1000\ \mu\text{F}$ capacitor through a resistor from a $6.0\ \text{V}$ battery. His voltage readings are plotted.

Time (s): 0, 10, 20, 30, 40, 60

Voltage (V): 0, 2.4, 3.8, 4.7, 5.2, 5.7

1. State the final capacitor voltage.
2. Find the time at which the voltage is 63 % of the final value.
3. Calculate the resistance of the resistor.
4. Calculate the initial current.



Measured charging data.

Problem 19 Spot the errors (hard)

A student answers two questions.

- (i) "In a single loop with a $12\ \text{V}$ battery and resistors of $2.0\ \Omega$ and $4.0\ \Omega$, the loop rule gives $12 + 2I + 4I = 0$, so $I = -2.0\ \text{A}$."
- (ii) "Adding a $10\ \Omega$ resistor in parallel with another $10\ \Omega$ resistor makes the total $20\ \Omega$."

1. Identify the mistake in (i) and give the correct current.

2. Identify the mistake in (ii) and give the correct total.

Problem 20 Dimming lamp (hard)

A battery has emf 6.0 V and internal resistance 1.0 Ω . A lamp of 5.0 Ω is connected to it.

1. Calculate the lamp power.
2. An identical 5.0 Ω lamp is added in parallel. Calculate the terminal voltage and the power of each lamp.
3. Explain why the first lamp dims.