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4C Quiz #3

This Quizz is closed book.
Make sure to always indicate positive directions and make large and neat figures. Specify the units of numerical answers.

PROBLEM 1 (points).

Two wires of length ℓ connect a battery with voltage V to a lightbulb with resistance R. One wire is made of copper (resistivity ρ), the other wire is made of aluminum (conductivity σ). Their diameters are D.

a. Calculate the resistances of the copper and the aluminum wires.

b. How much power is dissipated in the lightbulb? What are its units?

PROBLEM 2 (points).

A hairdryer is rated at 2 kW and is plugged into a wall socket.

a. What is the effective current through the hairdryer?

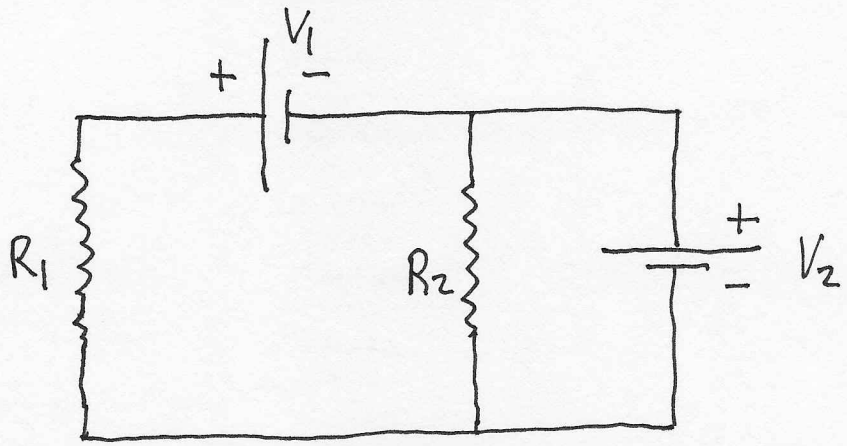
b. What DC voltage would give the same power dissipation as the AC voltage from the wall socket?

c. What is the instanteneous peak current?

d. Write an equation for the instanteneos AC current through the hairdryer.

PROBLEM 3 (points).

Two resistors and two batteries are connected as shown in the figure. The values of their resistances and voltages are indicated.

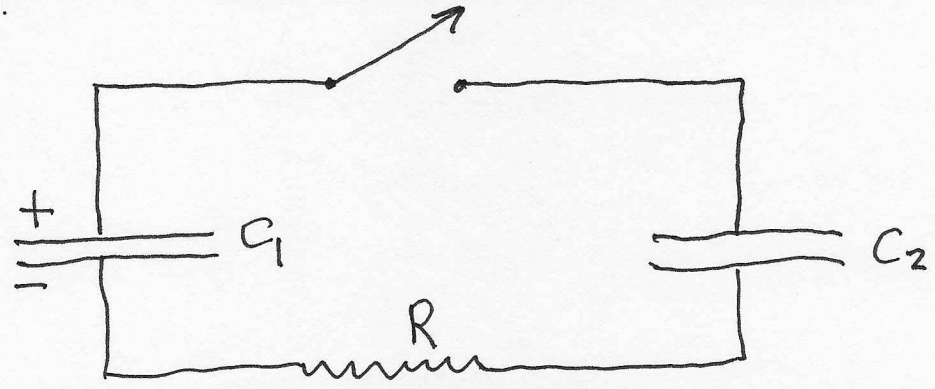


a. Calculate the current through each resistor. What are their units?

b. Calculate the power dissipated in each resistor. What are their units?

PROBLEM 4 (points).

Two batteries, a resistor, two capacitors, and a switch are connected as shown in the figure. The values of their capacitances, resistance, and voltages are indicated. Initially the switch is open, capacitor C_1 is charged to a voltage V_1 while the capacitor C_2 has no charge. The switch is closed at $t = 0$.



a. Calculate the instantaneous current in the loop immediately after the switch is closed.

b. Calculate the differential equation for the circuit with t as the independent variable. You may choose the dependent variable yourself, whichever is easiest. The current or the charge on one of the two capacitors would be good candidates but there should only be *one* dependent variable in the equation.

c. Eventually at $t = \infty$ the current in the loop will be zero. What is the condition that makes that happen?

d. What will be the charges Q_1 and Q_2 at $t = \infty$?

e. Compare the total potential energy of the two capactors at $t = 0$ and $t = \infty$. Are they the same? Why (not)?

PROBLEM 5 (points)

A vector potential $\boldsymbol{A}$ is given as $\boldsymbol{A} = C\,(x^2 + y^2)\,\boldsymbol{r}$ where $\boldsymbol{r} = (x, y, z)$ is the distance from the origin of the coordinate system and C is a constant.

a. What are the units of $\boldsymbol{A}$ if the units of a magnetic field are T (Teslas)?

b. Calculate the magnetic field $\boldsymbol{B}$.

c. Calculate the magnitude B of the magnetic field.

d. Calculate $\boldsymbol{r} \cdot \boldsymbol{B}$. What conclusion do you draw from your answer? Could you have known that looking at your answer in b)?