ECE241

HW #1

SOLUTIONS

Problems from "Introduction to Electric Circuits", Svoboda and Dorf, 9^{th} ed. Pages 45-51.

1) P 2.4-2
2) P 2.4-5
3) P 2.4-7
4) P 2.4-12
5) P 2.5-2
6) P 2.9-1

SOLUTIONS:

P 2.4-2 A current source and a resistor are connected in series in the circuit shown in Figure P 2.4-1. Elements connected in series have the same current, so $i = i_s$ in this circuit. Suppose that i = 3 mA and v = 24 V. Calculate the resistance R and the power absorbed by the resistor.

Answer: R = 8 kΩ and the resistor absorbs 72 mW.

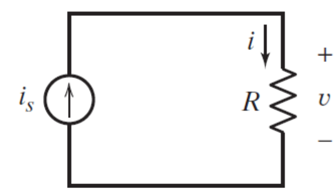
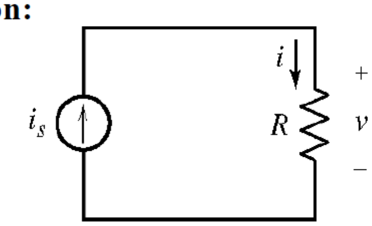


Figure P 2.4-1

Solution:



$$i = i_s = 3 \text{ mA and } v = 48 \text{ V}$$

$$R = \frac{v}{i} = \frac{48}{0.003} = 16000 = \underline{16\ \text{K}\Omega}$$

$$P = (3\times10^{-3})\times48 = 144\times10^{-3} = \underline{144\ \text{mW}}$$

P 2.4-5 A voltage source and two resistors are connected in parallel in the circuit shown in Figure P 2.4-5. Elements connected in parallel have the same voltage, so $v_1 = v_s$ and $v_2 = v_s$ in this circuit. Suppose that $v_s = 150$ V, $R_1 = 50\ \Omega$, and $R_2 = 25\ \Omega$. Calculate the current in each resistor and the power absorbed by each resistor.

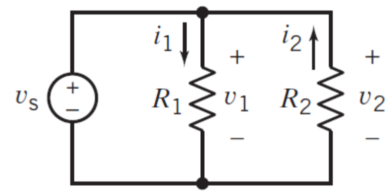
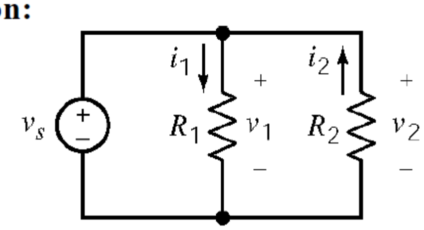


Figure P 2.4-5

Hint: Notice the reference directions of the resistor currents.
Answer: $i_1 = 3$ A and $i_2 = -6$ A. R_1 absorbs 450 W and R_2 absorbs 900 W.

Solution:



$v_1 = v_2 = v_s = 150$ V;

$R_1 = 50\ \Omega$; $R_2 = 25\ \Omega$

v_1 and i_1 adhere to the passive convention so

$$i_1 = \frac{v_1}{R_1} = \frac{150}{50} = \underline{3\text{ A}}$$

v_2 and i_2 do not adhere to the passive convention so $i_2 = -\dfrac{v_2}{R_2} = -\dfrac{150}{25} = \underline{-6\text{ A}}$

The power absorbed by R_1 is $P_1 = v_1 i_1 = 150 \cdot 3 = \underline{450\text{ W}}$

The power absorbed by R_2 is $P_2 = -v_2 i_2 = -150(-6) = \underline{900\text{ W}}$

P 2.4-7 An electric heater is connected to a constant 250-V source and absorbs 1000 W. Subsequently, this heater is connected to a constant 210-V source. What power does it absorb from the 210-V source? What is the resistance of the heater?

Hint: Model the electric heater as a resistor.

Solution:

Model the heater as a resistor, then from $P = \dfrac{v^2}{R} \Rightarrow R = \dfrac{v^2}{P} = \dfrac{(250)^2}{1000} = 62.5\ \Omega$

with a 220 V source $\qquad P = \dfrac{v^2}{R} = \dfrac{(220)^2}{62.5} = \underline{774.4\text{ W}}$

P2.4-12. We will encounter "ac circuits" in Chapter 10. Frequently we analyze ac circuits using "phasors" and "impedances". Phasors are complex numbers that represents currents and voltages in an ac circuit. Impedances are complex numbers that describe ac circuit elements. (See Appendix B for a discussion of complex numbers.) Figure P2.4-11 shows a circuit element in an ac circuit. **I** and **V** are complex numbers representing the element current and voltage. **Z** is a complex number describing the element itself. "Ohm's law for ac circuits" indicates that

$$\mathbf{V} = \mathbf{Z}\,\mathbf{I}$$

(a) Suppose $\mathbf{V} = 12\angle 45°\text{ V}$, $\mathbf{I} = B\angle\theta$ A and $\mathbf{Z} = 18 + j8\ \Omega$. Determine the values of B and θ.

(b) Suppose $\mathbf{V} = 48\angle 135°\text{ V}$, $\mathbf{I} = 3\angle 15°$ A and $\mathbf{Z} = R + jX\ \Omega$. Determine the values of R and X.

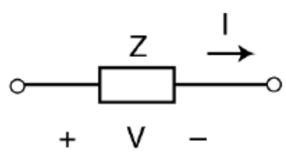


Figure P2.4-12

Solution:

(a)
$$12\angle 45° = (18 + j8)(B\angle\theta)$$

$$B\angle\theta = \frac{12\angle 45°}{18 + j8} = \frac{12\angle 45°}{19.7\angle 24°} = 0.609\angle 21°$$

so
$$B = 0.609 \text{ A and } \theta = 21°$$

(b)
$$48\angle 135° = (R + jX)(3\angle 15°)$$

$$R + jX = \frac{48\angle 75°}{3\angle 15°} = 18\angle 60° = 9 + j15.6\,\Omega$$

so
$$R = 9\ \Omega \quad \text{and } X = 15.6\ \Omega$$

P 2.5-2 A current source and a voltage source are connected in series with a resistor as shown in Figure P 2.5-2. All of the elements connected in series have the same current, i_s, in this circuit. Suppose that $v_s = 10$ V, $i_s = 2$ A, and $R = 5\ \Omega$. (a) Calculate the voltage v across the resistor and the power absorbed by the resistor. (b) Change the voltage source voltage to $v_s = 5$ V and recalculate the voltage, v, across the resistor and the power absorbed by the resistor.

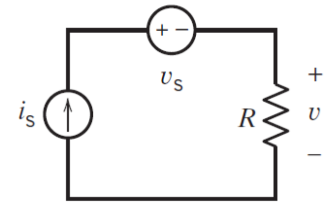


Figure P 2.5-2

Answer: $v = 10$ V and the resistor absorbs 20 W both when $v_s = 10$ V and when $v_s = 5$ V.

Solution:

(a) From Ohm's law $v = R\, i_s = 5(3) = 15\ \text{V}$. (The resistor voltage does not depend on the voltage source voltage.) Next $P = \dfrac{v^2}{R} = \dfrac{15^2}{5} = \underline{45\ \text{W}}$.

(b) Since v and P do not depend on v_s the values of v and P are 15 V and 45 W both when $v_s = 10\text{V}$ and when $v_s = 5\text{V}$.

P 2.9-1 Determine the current, i, at $t = 1$ s and at $t = 4$ s for the circuit of Figure P 2.9-1.

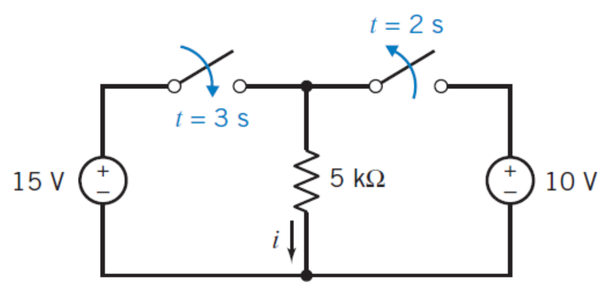
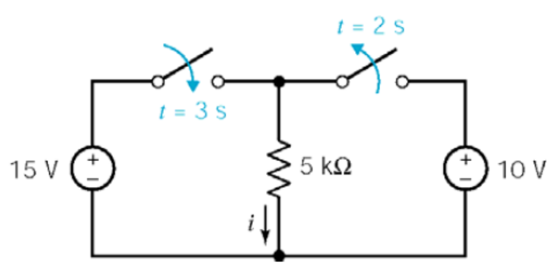


Figure P 2.9-1

Solution:



At $t = 1$ s the left switch is open and the right switch is closed so the voltage across the resistor is 10 V.

$$i = \frac{v}{R} = \frac{10}{5\times 10^3} = \underline{2\ \text{mA}}$$

At $t = 4$ s the left switch is closed and the right switch is open so the voltage across the resistor is 15 V.

$$i = \frac{v}{R} = \frac{15}{5\times 10^3} = \underline{3\ \text{mA}}$$