ECSE 200 - Electric Circuits 1
Turotial 1 - Problem set 2

ECE Dept., McGill University

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Recall

- **Passive element**: a circuit element that **cannot** deliver more energy than it has already received from a circuit. In other words, the absorbed energy of this element is **non-negative**.

$$U(t) = \int_{-\infty}^{t} p(t')\partial d' = \int_{-\infty}^{t} v(t')i(t')\partial d' \geq 0$$

- **Active element**: a circuit element that **can** deliver more energy than it has already received from a circuit. In other words, the absorbed energy of this element is **non-positive**.

$$U(t) = \int_{-\infty}^{t} p(t')\partial d' = \int_{-\infty}^{t} v(t')i(t')\partial d' \leq 0$$

Recall (cnt.)

- **Linear circuit element**: a circuit element which has the terminal voltage and current related to each other by a linear function.
- **Ohm's Law**: the voltage drop v across an **ideal resistor** is proportional to the current i flowing through this resistor.

$$v = iR \text{ (V)}$$

$\Rightarrow$ An **idea resistor** is a linear circuit element.

Recall (cnt.)

- **Resistance,** R**, and Conductance,** G:

$$G = \frac{1}{R}\ (\mathrm{S}),\ \text{and}\ R = \frac{1}{G}\ (\Omega)$$

- **Power**

$$p(t) = i(t)v(t) = i^2(t)R = \frac{v^2(t)}{R}\ (\mathrm{W})$$

Recall (cnt.)

- **Independent voltage source**: $V_s = const.$ regardless of I_{V_s}
- **Dependent voltage source**: V_s is independent of I_{V_s}, but is dependent on a voltage or a current elsewhere in the circuit.
  - Voltage-controlled voltage source (VCVS)

    $V_{VCVS} = \mu V_0$ (V), where V_0 is a voltage elsewhere in the circuit.
  - Current-controlled voltage source (CCVS)

    $V_{CCVS} = rI_0$ (V), where I_0 is a current elsewhere in the circuit.

Recall (cnt.)

- **Independent current source**: $I_s = const.$ regardless of V_{I_s}
- **Dependent current source**: I_s is independent of V_{I_s}, but is dependent on a voltage or a current elsewhere in the circuit.
  - Voltage-controlled current source (VCCS)

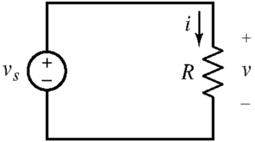
    $I_{VCCS} = gV_0$ (A), where V_0 is a voltage elsewhere in the circuit.

  - Current-controlled current source (CCCS)

    $I_{CCCS} = \beta I_0$ (A), where I_0 is a current elsewhere in the circuit.

Problem P 2.4-4

Given a voltage source and a resistor connected as shown in the below circuit. Elements connected in parallel have the same voltage. Suppose that $v_s = 24$ V and $i = 3$ A. Calculate the resistance R and the power absorbed by the resistor.



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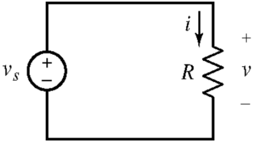

Solution:

$$R = \frac{v}{i} = \frac{v_s}{i} = \frac{24}{3} = 8 \ (\Omega)$$

$$p = vi = 24 \times 3 = 72 \ (\mathrm{W})$$

Problem 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 220-V source. What power does it absorb from the 220-V source ? What is the resistance of the heater ?

Problem summary:

Given a resistor R, $p_1 = 1000$ W when $v_1 = 250$ V $\Rightarrow R = ?$
If $v_2 = 220$ V then $p_2 =?$

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Problem summary:

Given a resistor R, $p_1 = 1000$ W when $v_1 = 250$ V $\Rightarrow R = ?$
If $v_2 = 220$ V then $p_2 =?$

Solution:

$$\text{Since } p_1 = \frac{v_1^2}{R} \Rightarrow R = \frac{v_1^2}{p_1} = 62.5\ (\Omega)$$

$$p_2 = \frac{v_2^2}{R} = 774.4\ (\text{W})$$

Problem P 2.5-4

Given a current source and a voltage source connected as shown in the below circuit. Suppose that $v_s = 12$ V and i_s=2 A. Calculate the power **supplied** by each source.

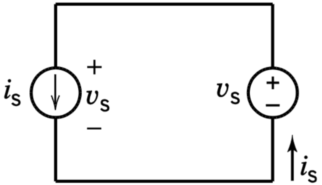


Figure P 2.5-4

Problem P 2.5-4

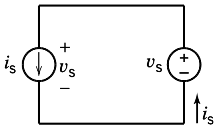


Figure P 2.5-4

- Consider the **voltage source** as a **passive element**, the power received by the voltage source is: $p_{VS} = v_s(-i_s) = 12 \times (-2) = -24$ (W). Hence, the **voltage source supplies** 24 (W).

- Consider the **current source** as a **passive element**, the power received by the current source is: $p_{CS} = v_s i_s = 12 \times 2 = 24$ (W). Hence, the **current source supplies** -24 (W).

Problem P 2.6-1

For the circuit of Fig. P 2.6-1, find the value of the resistance R the power **delivered by** the voltage source.

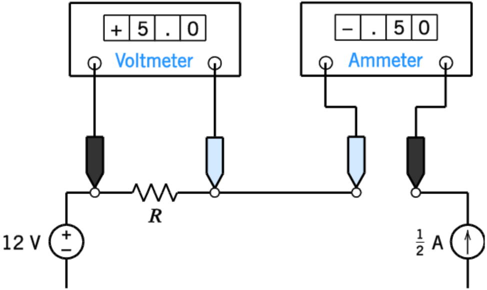


Figure P 2.6-1

Problem P 2.6-1

Solution:

- Since the resistor R is an passive element, therefore $R = \frac{5}{-(-0.5)} = 10\ (\Omega)$.
- Consider the voltage source as an **active element**, the power delivered by this source is $P = V_s I_s = 12 \times (-0.5) = -6(\text{ W})$.

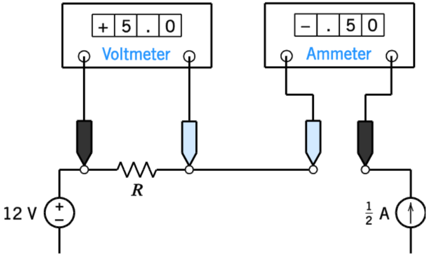


Figure P 2.6-1

Problem P 2.7-2

The ammeter in circuit shown in Fig. P 2.7-2 indicates that $i_a = 2$ (A), and the voltmeter indicates that $v_b = 8$ (V). Determine the gain value, g, of the voltage-controlled current source (VCCS) shown in the circuit.

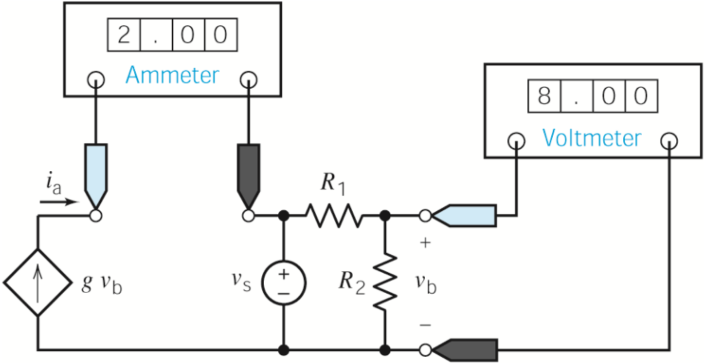


Figure P 2.7-2

Problem P 2.7-2

Solution: The current i_a has a positive value of 2 (A), which indicates that i_a is produced by the VCCS, therefore $i_a = gv_b \Rightarrow g = \frac{i_a}{v_b} = \frac{2}{8} = 0.25\ \frac{A}{V}$

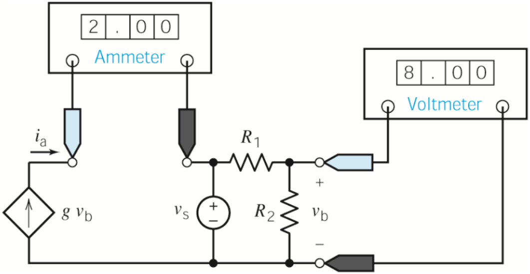


Figure P 2.7-2

Problem P 2.7-4

The voltmeters in circuit shown in Fig. P 2.7-4 indicates that $v_a = 2$ (V), and $v_b = 8$ (V). Determine the gain value, g, of the voltage-controlled voltage source (VCVS) shown in the circuit.

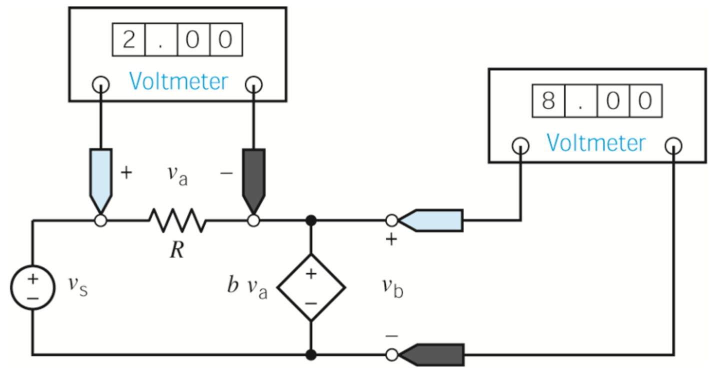


Figure P 2.7-4

Problem P 2.7-4

<u>Solution:</u> $v_b = bv_a \Rightarrow b = \frac{v_b}{v_a} = \frac{8}{2} = 4\ \frac{V}{V}$

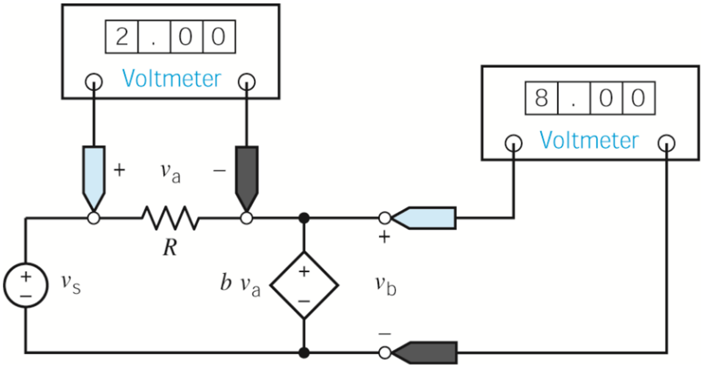


Figure P 2.7-4

Problem P 2.7-5

The values of the current and voltage of each circuit element are shown in Figure P 2.7-5. Determine the values of the resistance, R, and the gain of the dependent source, A.

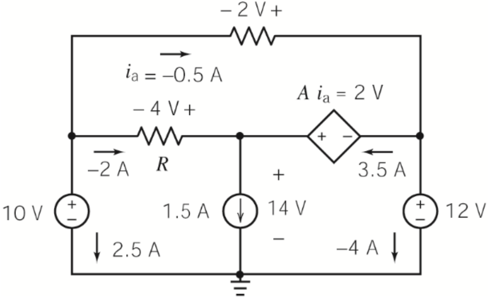


Figure P 2.7-5

Problem P 2.7-5

$$R = \frac{-4}{-2} = 2\ (\Omega) \text{ and } A = \frac{2}{i_a} = \frac{2}{-0.5} = -4\ (\frac{V}{A})$$

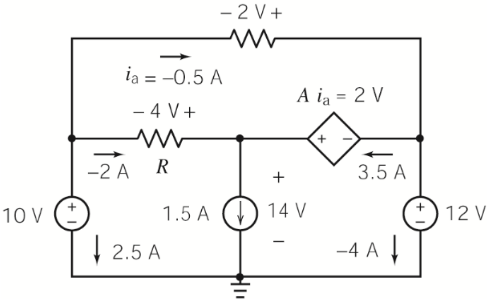


Figure P 2.7-5

Problem P 2.7-6

Find the power supplied by the VCCS in Fig. P 2.7-6.

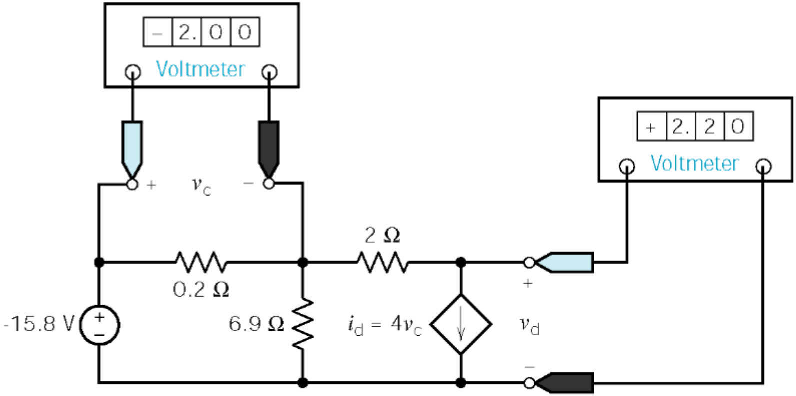


Figure P 2.7-6

Problem P 2.7-6

Solution: From the values indicated by the voltmeters, we have $i_d = 4v_c = 4 \times (-2) = -8$ (A). Consider the VCCS as a passive element, the power absorbed from this source is:

$$p_{VCCS} = v_d i_d = 2.2 \times (-8) = -17.6 \text{ (W)}.$$

Therefore, the power supplied by this source is 17.6 (W).

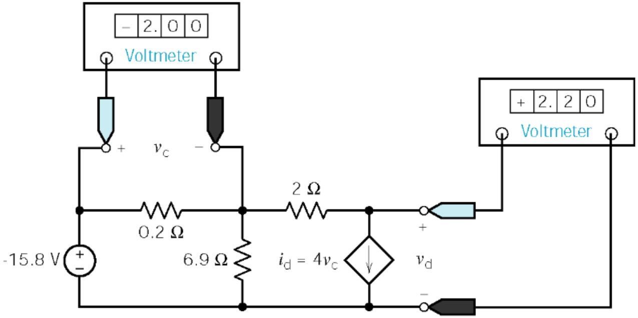
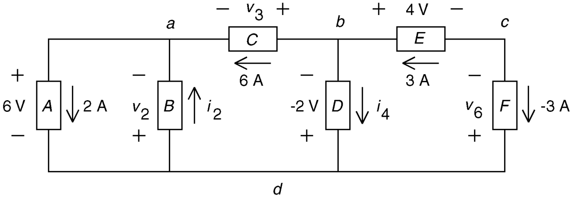


Figure P 2.7-6

Problem P 3.2-2

Determine the values of i_2, i_4, v_2, v_3 and v_6 in the following figure.



Problem P 3.2-2

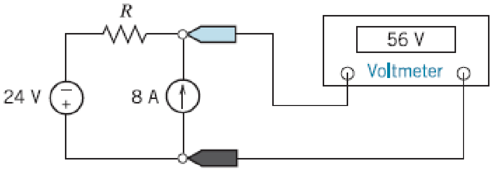
<u>Solution:</u>

- Apply KCL at node (a) to get $2 + i_2 + 6 = 0 \Rightarrow i_2 = 4(A)$.
- Apply KCL at node b to get $3 = i_4 + 6 \Rightarrow i_4 = -3(A)$.
- Apply KVL to the loop consisting of elements A and B to get $-v_2 – 6 = 0 \Rightarrow v2 = -6(V)$.
- Apply KVL to the loop consisting of elements C, D, and A to get $-v_3 - (-2) – 6 = 0 \Rightarrow v4 = -4(V)$.
- Apply KVL to the loop consisting of elements E, F and D to get $4 - v_6 + (-2) = 0 \Rightarrow v6 = 2(V)$.

Check: The sum of the power supplied by all branches is
$-(6)(2) – (-6)(-4) – (-4)(6) + (-2)(-3) + (4)(3) + (2)(-3) =$
$-12 - 24 + 24 + 6 + 12 – 6 = 0$. Yes!

Problem P 3.2-8

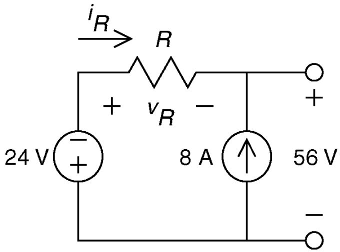
The voltmeter in Figure P 3.2-8 measures the value of the voltage across the current source to be 56 V. What is the value of the resistance R? *Hint:* Assume an ideal voltmeter. An ideal voltmeter is equivalent to an open circuit.



Problem P 3.2-8

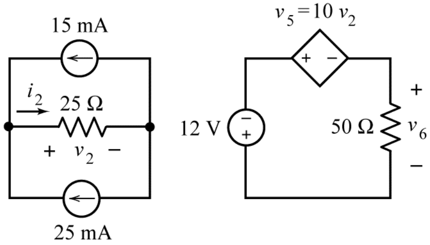
<u>Solution:</u>

- Apply KCL at node b to get $i_R + 8 = 0 \Rightarrow V_R = -8(A)$.
- Apply KVL to the loop to get $V_R + 56 + 24 = 0 \Rightarrow V_R = -80(V)$.
- Then, we have $R = \frac{-80}{-8} = 10(\Omega)$



Problem P 3.2-20

Determine the value of the voltage v_6 for the circuit shown in the following figure.



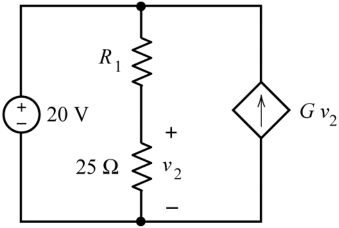
Problem P 3.2-20

Solution:

- Apply KCL at the left node: $i_2 = 0.015 + 0.025 = 0.04(A)$
- From Ohm's law $v_2 = 25i_2 = 25(0.04) = 1(V)$
- Use the element equation of the dependent source:
  $v_5 = 10v_2 = 10(V)$
- Apply KVL to the right mesh
  $v_5 + v_6 + 12 = 0 \Rightarrow v_6 = -v_5 - 12 = -10 - 12 = -22(V)$

Problem P 3.2-25

The voltage source in the circuit shown in Figure P3.2-25 supplies 2 W of power. The value of the voltage across the 25Ω resistor is $v_2 = 4$ V. Determine the values of the resistance R_1 and of the gain, G, of the CCVS.



Problem P 3.2-25

Solution:

- The voltage source current is calculated from the values of the source voltage and power: $i_s = \frac{2}{20} = 0.1(A)$
- Apply KCL at the bottom node to get:
  $i_s + Gv_2 = \frac{v_2}{25} \Rightarrow 0.1 + 4G = \frac{4}{25} \Rightarrow G = 15(mA/V)$
- Next, use Ohm's law to determine the value of the resistance R1:
  $R_1 = \frac{20 - v_2}{\frac{v_2}{25}} = 100(\Omega)$.

Thank you !