EE 111 Homework 2

Due date: Mar. 20^{th}, 2019

Turn in your homework in class

Rules:

- Work on your own. Discussion is permissible, but similar submissions will be judged as plagiarism.
- Please show all intermediate steps: a correct solution without an explanation will get zero credit.
- Please submit on time. No late submission will be accepted.
- Please prepare your submission in English only. No Chinese submission will be accepted.

1. Linear Property

(1) For the circuits in Figure 1.1, use linearity to find the value of v_0.

Hint: First, assume $v_0 = 4\,\text{V}$ and calculate the voltage of the DC source. Next, use linearity to find v_0 with the known DC voltage source of 2 V.

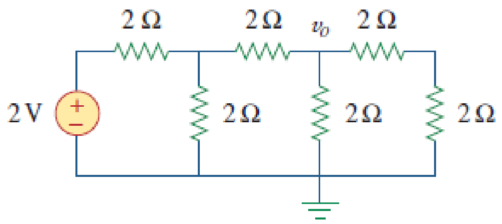

Figure 1.1

(2) In a complex linear system (consists of independent sources, dependent sources and resistors), there are only two independent sources: one voltage source V_S and one current source I_S. A current through one branch of this complex linear system is I.

Given that $I = 8\,\text{A}$ when $V_S = 10\,\text{V}$ and $I_S = 4\text{A}$; $I = 10.5\,\text{A}$ when $V_S = 12\,\text{V}$ and $I_S = 6\,\text{A}$.

(2.a) Find the current I when $V_S = 22\,\text{V}$ and $I_S = 10\,\text{A}$ and the current I when $V_S = 2\,\text{V}$ and $I_S = 2\,\text{A}$.

(2.b) Find the current I when $V_S = 15\,\text{V}$ and $I_S = 8\,\text{A}$ (you should be able to find the current I with any given V_S and I_S).

2. Superposition principle

(1) Use the superposition principle to find i_0 and v_0 in the circuit of Figure 2.1.

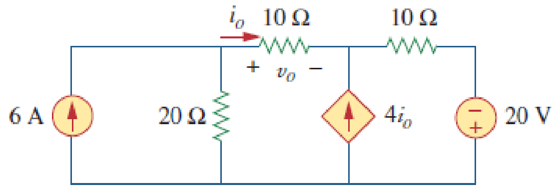

Figure 2.1

(2) Use the superposition principle to find v_0 in the circuit of Figure 2.2.

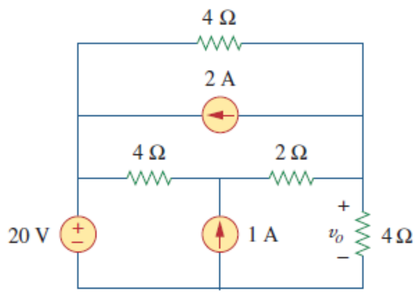

Figure 2.2

3. Thevenin & Norton

Find the Thevenin and Norton equivalent circuit between terminals *a* and *b* in the following figures.

(1) Figure 3.1 (with independent sources only)

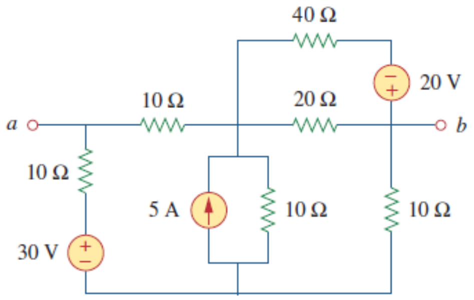

Figure 3.1

(2) Figure 3.2 (with independent and dependent sources)

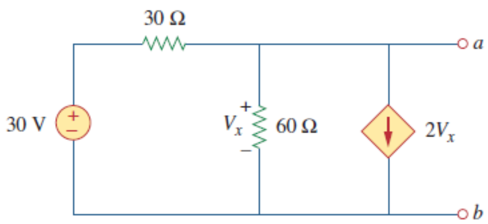

Figure 3.2

(3) Figure 3.3 (with dependent sources only)

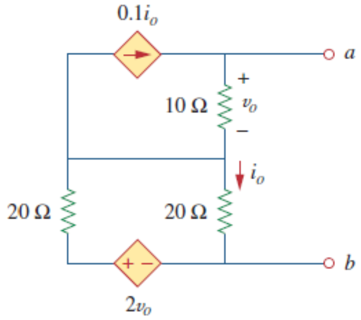

Figure 3.3

4. Source Transformation

Obtain v_0 in the circuit of Figure 4 using source transformation.

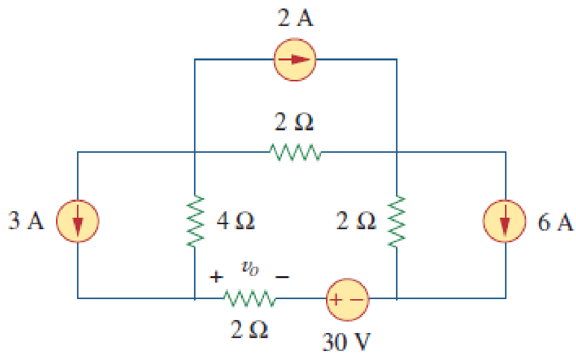

Figure 4

5. Max Power Transfer

Compute the value of R that results in maximum power transfer to the $10\,\Omega$ resistor (in series with the voltage source) in Figure 5. Find the maximum power.

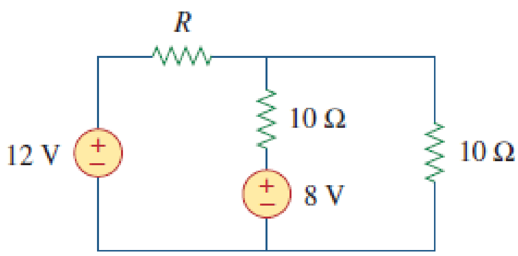

Figure 5

6. Operational Amplifiers

(1) Figure 6.1 demonstrates an example difference amplifier. Find v_0 given $v_1 = 2\,\text{V}$ and $v_2 = 3\,\text{V}$.

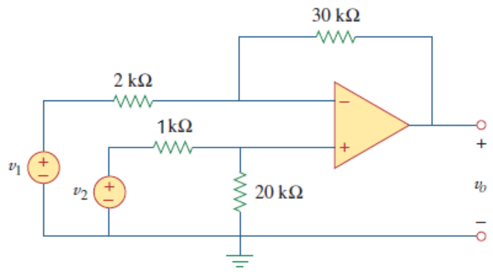

Figure 6.1

(2) Determine the gain v_0 / v_i in Figure 6.2.

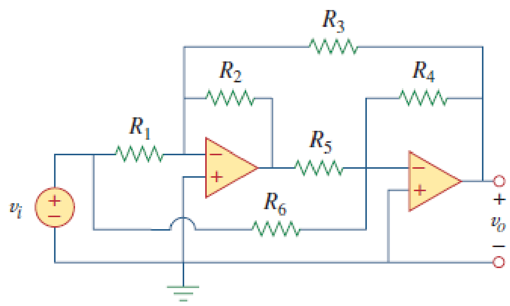

Figure 6.2

(3) Find the Thevenin equivalent circuit at terminals *a* and *b*.

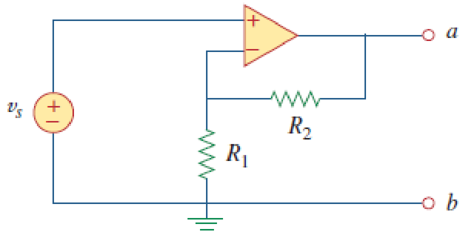

Figure 6.3

(4) In class we mentioned the "voltage follower" as shown in Figure 6.4.1. However, from the "virtual open" and "virtual short" of the ideal operational amplifier, it seems that the circuit in Figure 6.4.2 can also achieve the same function as that in Figure 6.4.1. Explain the reason why in practice the circuit in Figure 6.4.1 can work as the "voltage follower" while the circuit in Figure 6.4.2 cannot.

Hint: Consider non-ideal models of operational amplifiers. Assume that both amplifiers are powered by voltage sources $\pm V_{CC}$ $(V_{CC} > 0)$ and with the open loop gain of *A*. We can first assume that for both circuit $v_0 = v_i$ in the steady state. In practice, v_0 may differ from v_i a little bit due to environmental noises, with the voltage $v_0 = v_i + \Delta v$ or $v_0 = v_i - \Delta v$, where $\Delta v > 0$. Afterwards, try to explain what will happen inside both circuits.

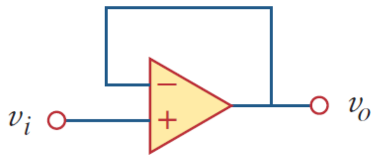

Figure 6.4.1

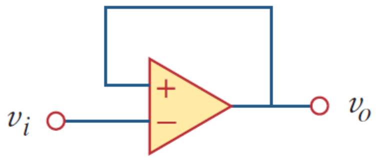

Figure 6.4.2