UNIVERSITY OF ALASKA FAIRBANKS

Department of Electrical and Computer Engineering

INTRODUCTION TO ELECTRICAL AND COMPUTER ENGINEERING

EE F102-F01
CRN: 32862

SPRING
2023

LECTURE 6

Monday
06 FEB 2023
DU 252
09:15 – 10:15

Instructor
MAHER AL-BADRI

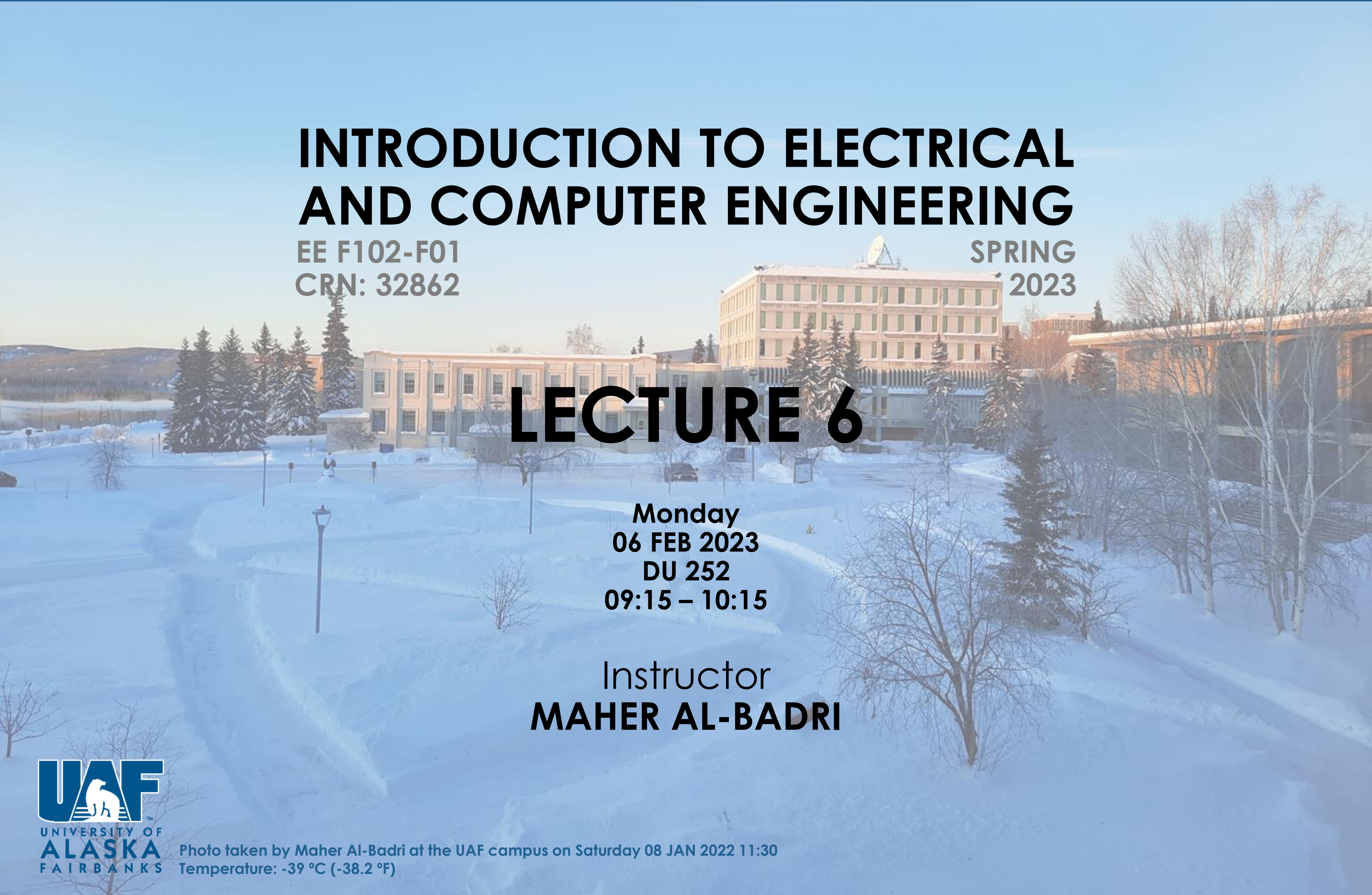


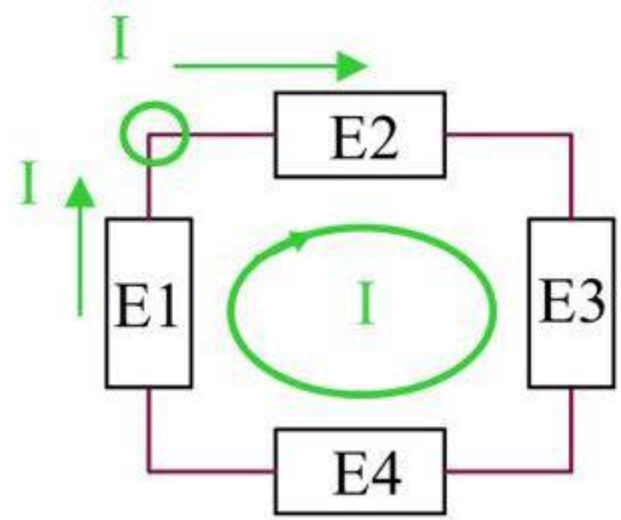
Photo taken by Maher Al-Badri at the UAF campus on Saturday 08 JAN 2022 11:30
Temperature: -39 °C (-38.2 °F)

Outline

- BASIC LAWS (II)
- PARALLEL AND SERIES CIRCUITS
- MEASURING CURRENT AND VOLTAGE
- CIRCUIT ANALYSIS
- SOURCES
- EXAMPLE PROBLEMS

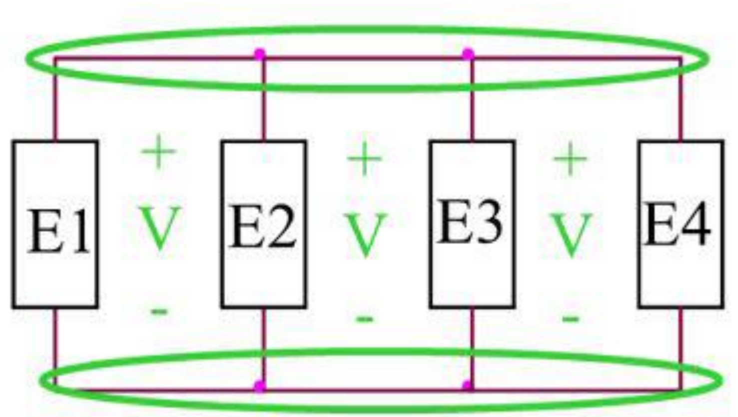
Parallel and Series Circuits

Two branches are in series if they are connected by a single node and no other branch is connected to that same node.



Parallel and Series Circuits

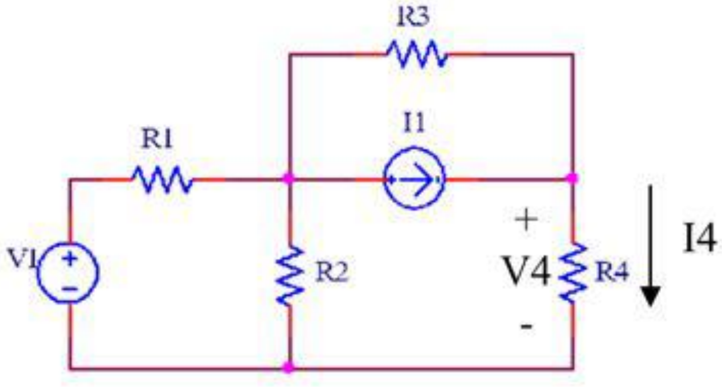
Two branches are in parallel if they are connected directly to the same two nodes.



Measuring Current and Voltage

In the circuit shown, we want to **measure the current I_4 through R_4**.

In order to make this measurement **the charge (current) needs to pass through the ammeter**.

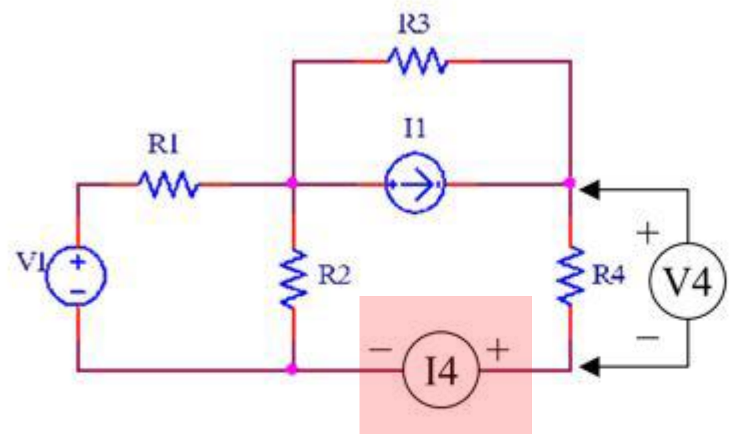


(a)

Measuring Current and Voltage

Physically, the **circuit must be broken in the path of the desired current and an ammeter put in-line with that path** as shown.

The polarization of the ammeter must be in passive sign convention **with the desired current direction**.

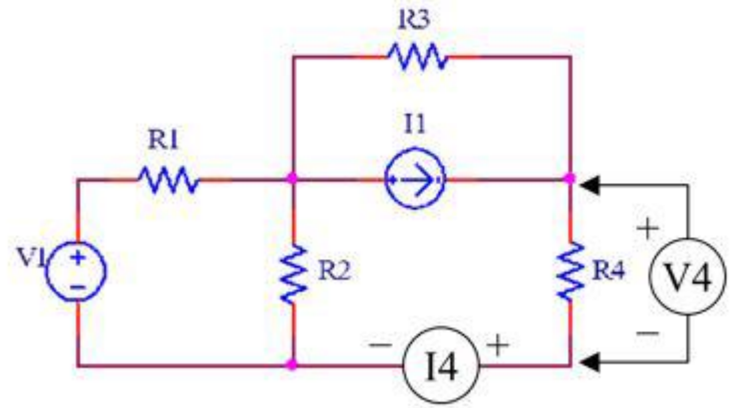


(b)

Measuring Current and Voltage

Any **voltage drop across the ammeter** will change the measured current.

In this class we will assume an **ideal ammeter with zero internal resistance**, so the voltage drop across the meter is **zero**.



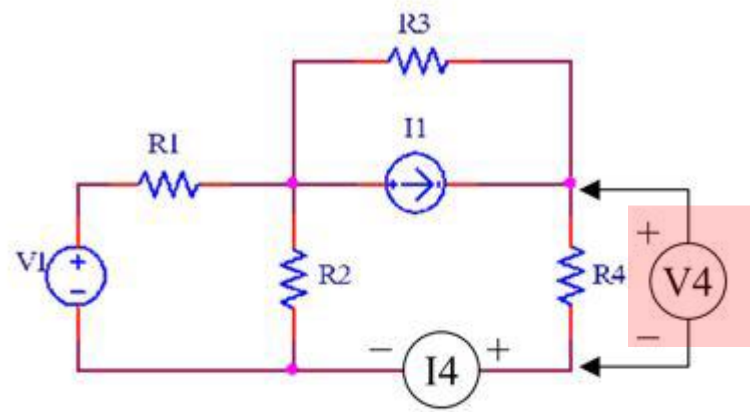
(b)

Measuring Current and Voltage

We would also like to **measure the voltage across R_4**.

We need to put the meter **in parallel** with R_4.

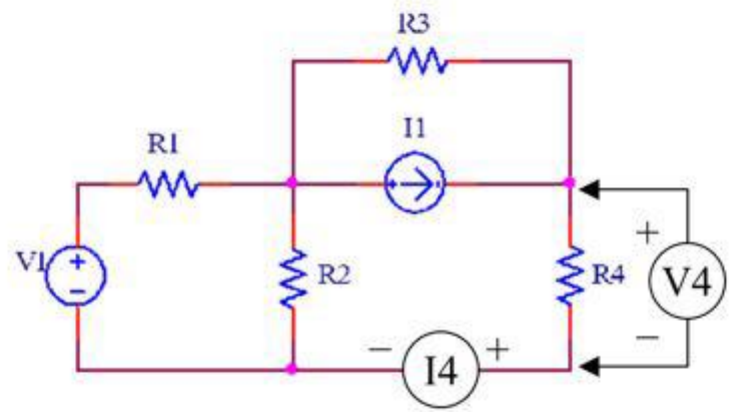
We need to connect the voltmeter across R_4 in the **same polarity** of the desired measurement.



(b)

Measuring Current and Voltage

In this class we will assume an **ideal voltmeter with infinite internal resistance**, so the current passing through (leaking) the meter will be **zero**.

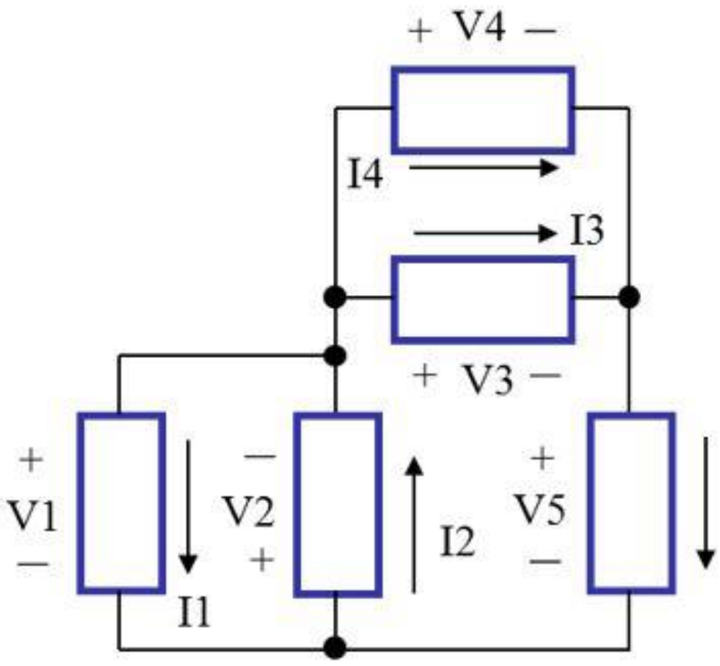


(b)

Circuit Analysis

Circuit analysis is based on laws.

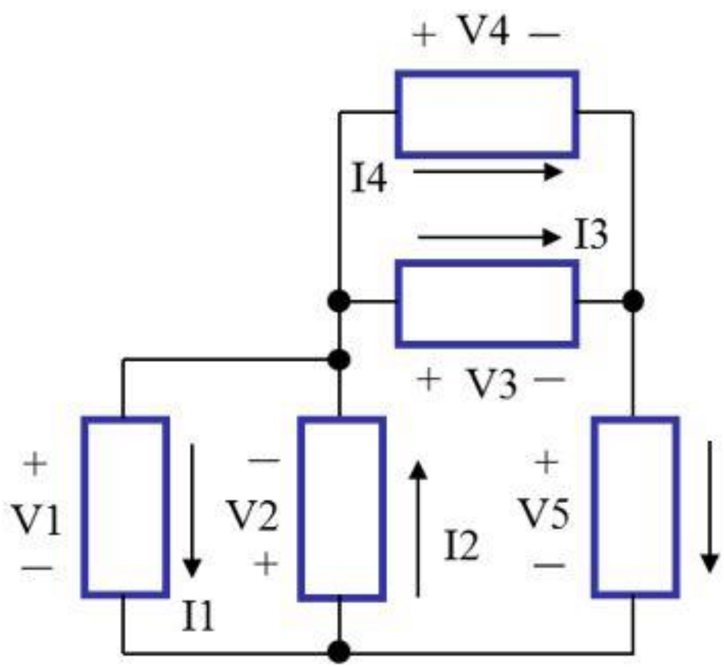
It is used to solve for **unknown voltages and currents** from which all other variables can be derived.



Circuit Analysis

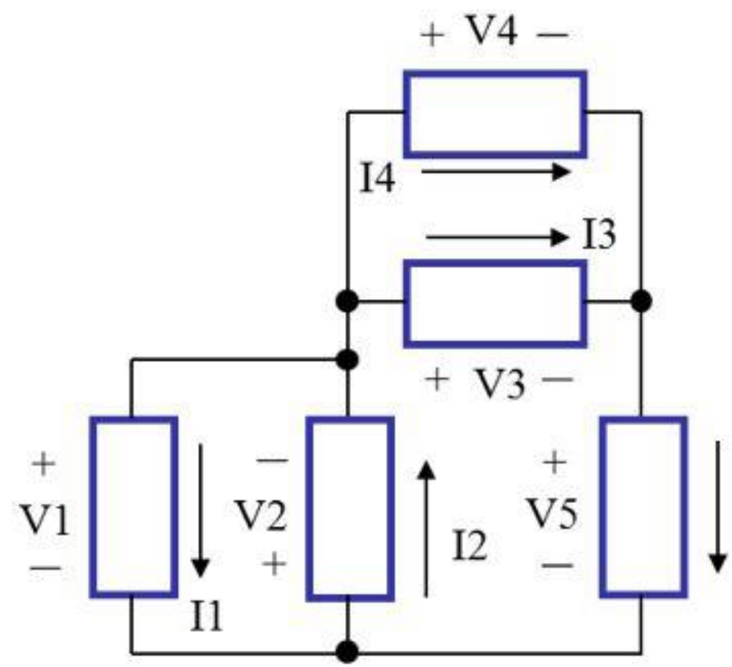
For the circuit shown, we would like to determine all **currents** through and **voltages** across all elements in the circuit.

Where do we start?



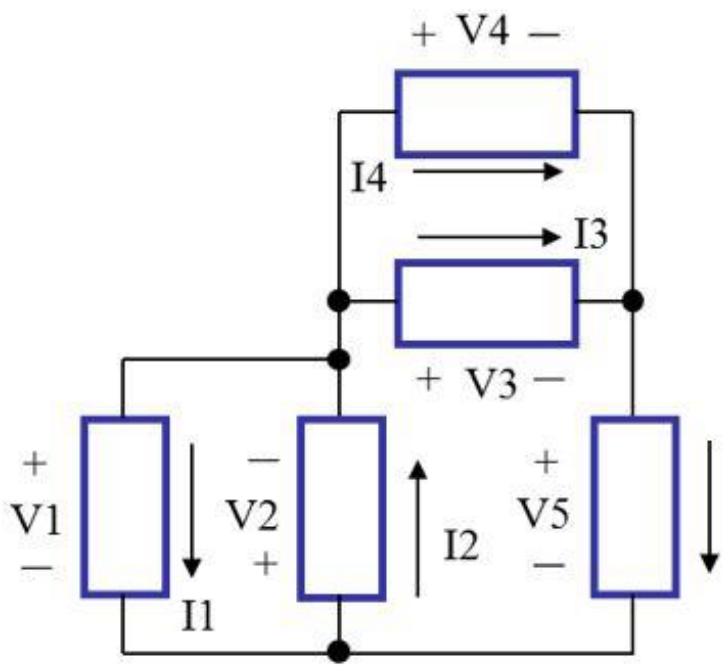
Circuit Analysis

1. **Arbitrarily** choose **either** the **voltage polarity** or **current directions** for the measured voltages or currents.



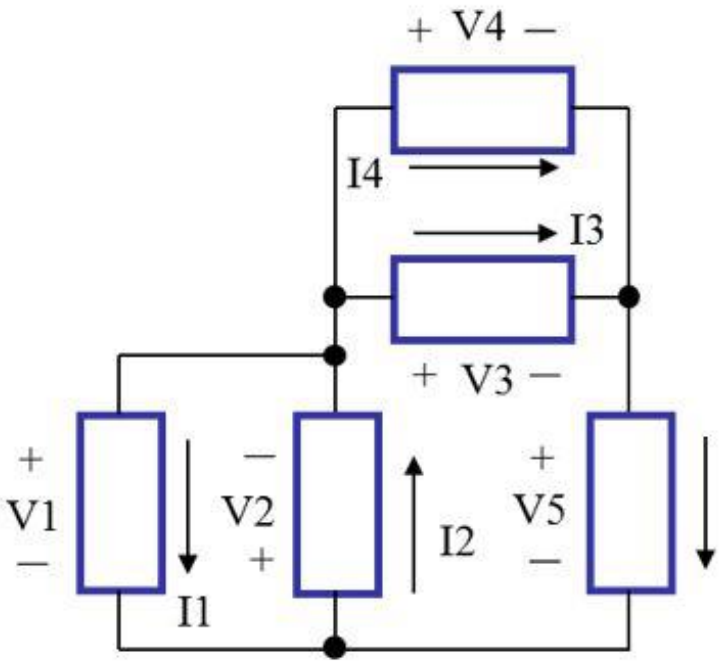
Circuit Analysis

2. Use **passive sign convention** to specify the required measured current direction or voltage polarity for the measurement not specified in Step 1.



Circuit Analysis

3. Apply **KVL** and/or **KCL** and/or **conservation of energy** to solve for all unknowns.

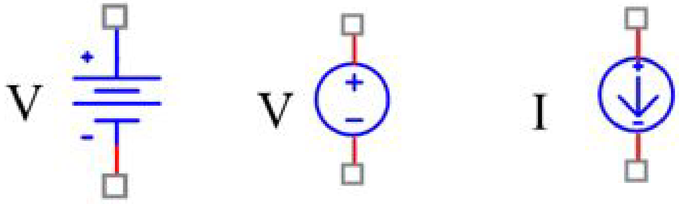


Sources

Ideal Independent Sources

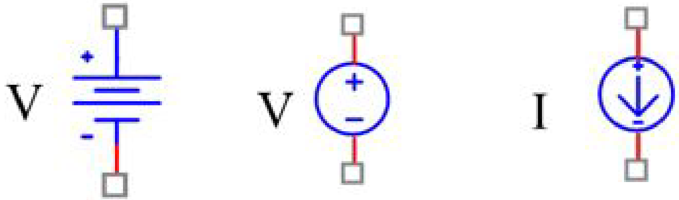
The figure shows some symbols for **direct current** or **DC sources**.

The two on the left are **voltage sources** and the one on the right is a **current source**.



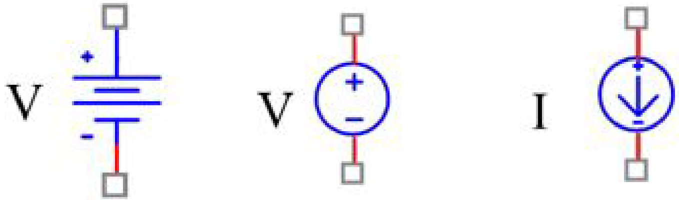
Sources

An **ideal voltage source provides a <u>constant voltage</u> across its terminals** (regardless the value of current).



Sources

An **ideal current source provides a <u>constant current</u> passing through it** (regardless the value of voltage).

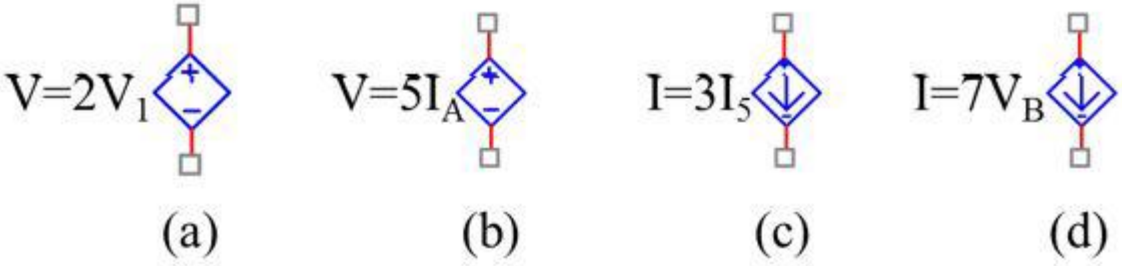


Sources

Ideal Dependent Sources

A **dependent source** can be either a voltage source or a current source.

The output of a dependent source is controlled by a voltage or current which exist in a different part of the circuit.

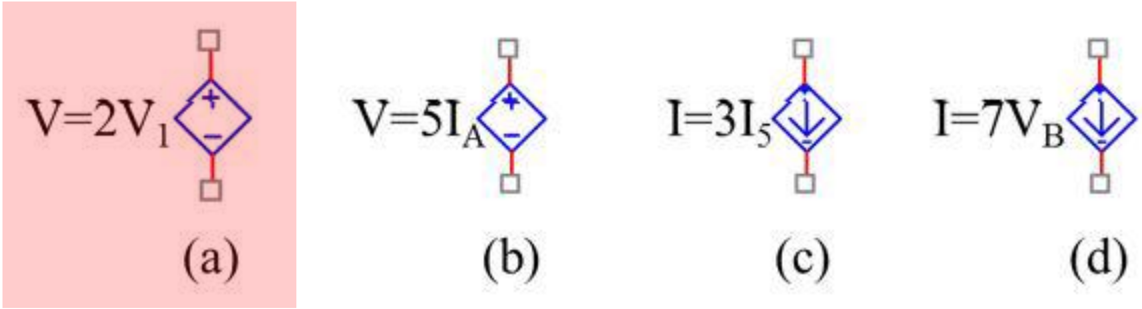


Sources

Ideal Dependent Sources

There are four different types of dependent sources:

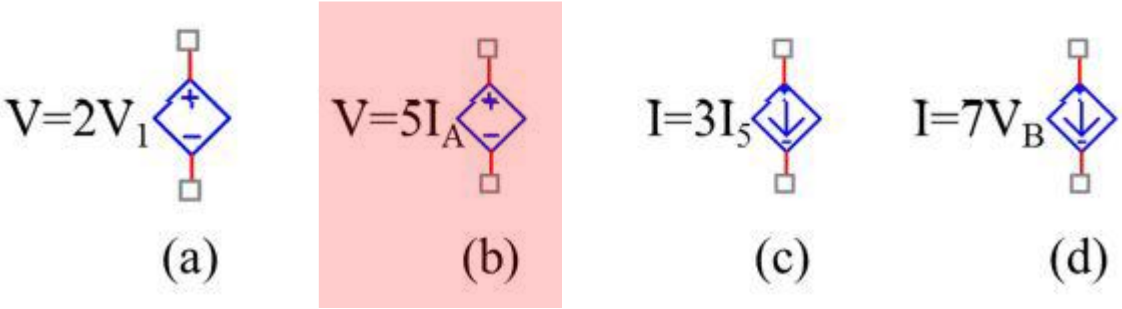
(a) Voltage Controlled Voltage Source



Sources

Ideal Dependent Sources

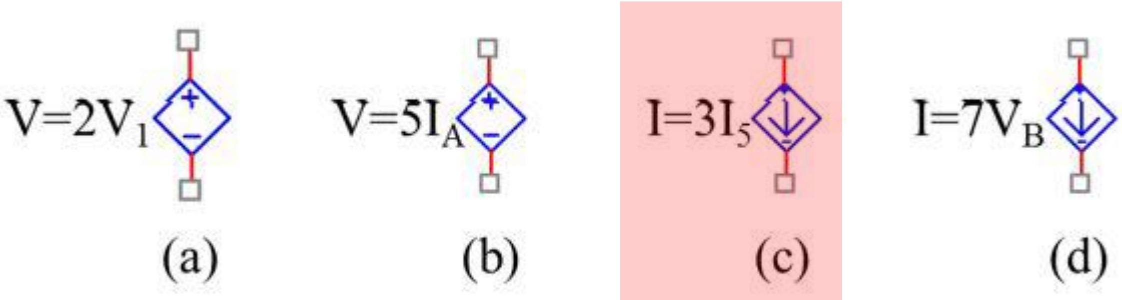
(b) Current Controlled Voltage Source



Sources

Ideal Dependent Sources

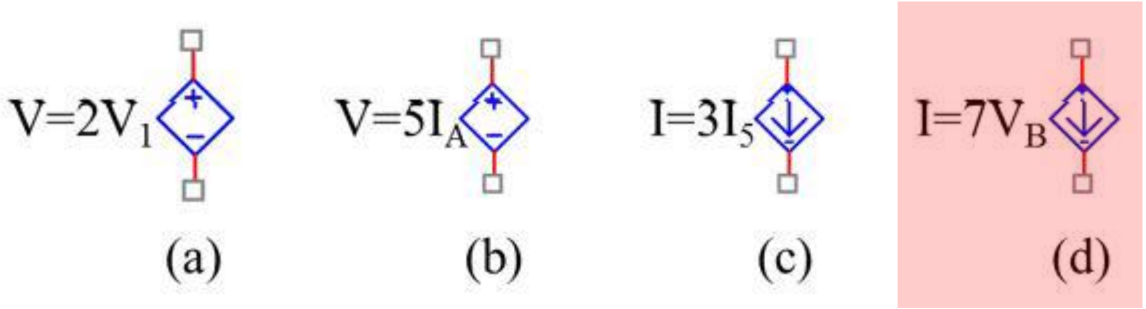
(c) Current Controlled Current Source



Sources

Ideal Dependent Sources

(d) Voltage Controlled Current Source

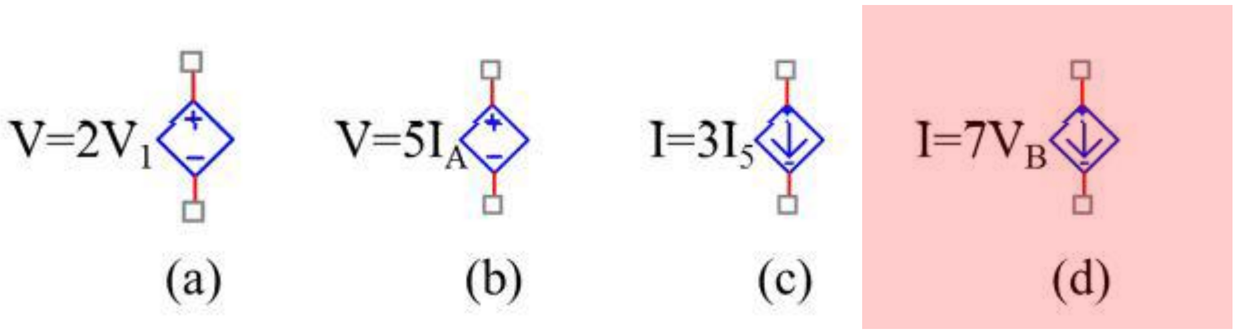


Sources

Ideal Dependent Sources

$I = 7V_B$

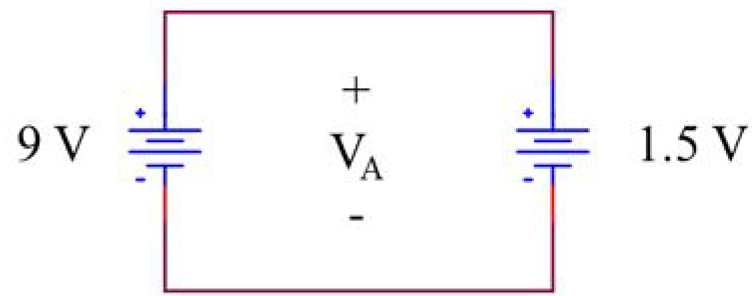
where, V_B is measured somewhere else in the circuit.



Sources

Real Sources

What happens when you connect a **9 V** battery in parallel with a **1.5 V** battery as shown?



Applying KVL around this circuit seems to **fail**!

What is wrong?

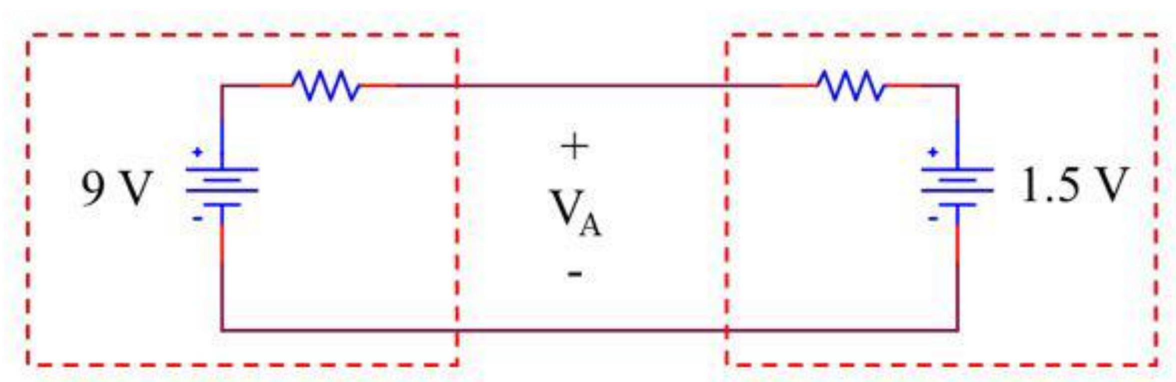
Sources

Real Sources

The problem is in **modeling** a **real source** using the previous circuit!

The chemical reaction inside the battery controls the rate of electrons that can flow between the terminals limiting the maximum current.

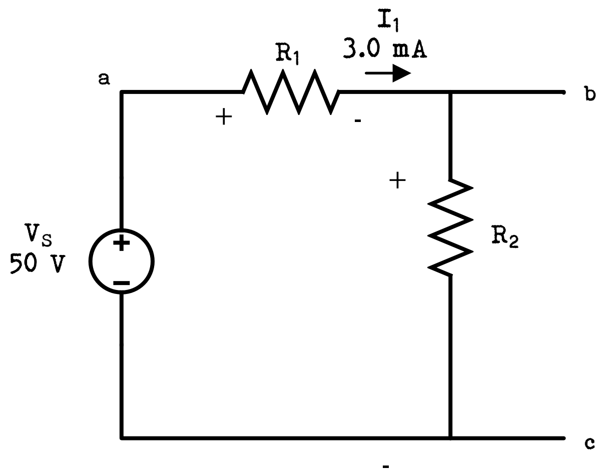
We model the effect of the chemical reaction as an **internal resistance**.



Example Problems

Example 6-1

For the circuit shown, the voltage across $\boldsymbol{R_1}$ is measured by an ideal voltmeter, and its value is found to be **30.5 V**. If the voltmeter is connected across the terminal bc.
Determine the voltmeter reading $(\boldsymbol{V_{bc}})$.
Determine the power consumed in each resistor.
Determine the total power supplied by the voltage source.

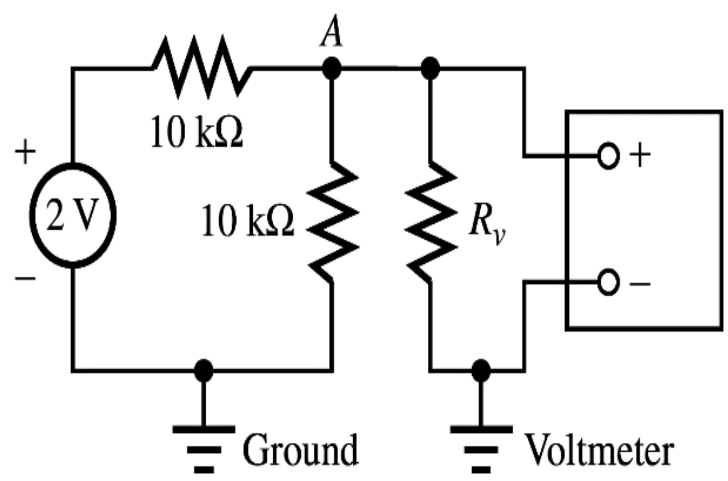


Example 6-1 will be explained on the whiteboard

Example Problems

Example 6-2

An electronic voltmeter with internal resistance (**Rv**) of **10 MΩ** is used to measure the potential difference between node A and the ground of the circuit shown in the figure. The voltmeter reads **1 V**.
If the voltmeter is connected across the terminals of **R1**. What would be the voltage reading?



Example 6-2 will be explained on the whiteboard

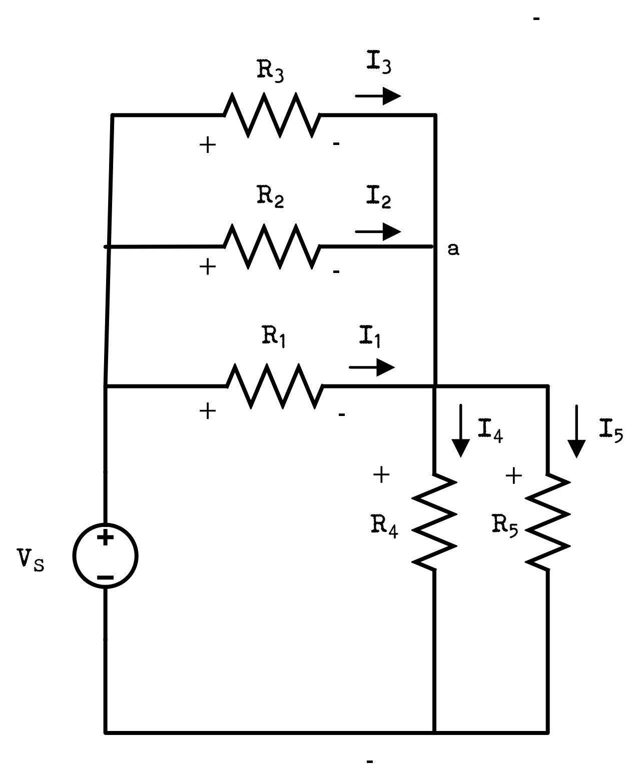
Example Problems

Example 6-3

For the circuit shown, the following data is available:

$$V_S = 6\,V$$
$$I_S = 31.935\,mA$$
$$V_a = 4.258\,V$$
$$P_1 = 30.343\,mW$$
$$I_2 = 8.710\,mA$$
$$I_5 = 10.645\,mA$$

Calculate I_1, I_3, I_4, and the total power supplied by the source.



Example 6-3 will be explained on the whiteboard

Additional notes will be given on the whiteboard

References

[1] **Denise Thorson**, "Introduction to Electrical and Computer Engineering," University of Alaska Fairbanks, 2018.