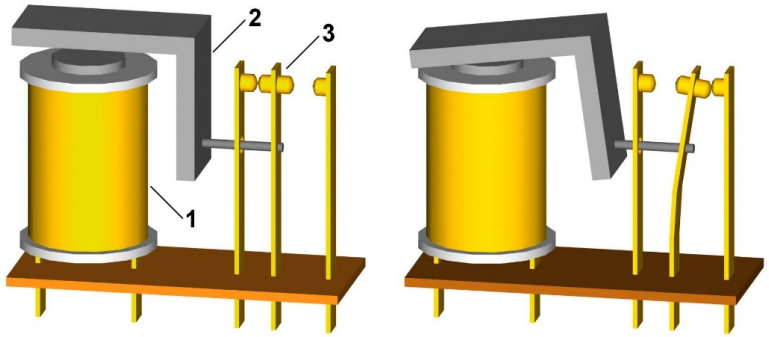
Reference videos

- Capacitors explained: https://www.youtube.com/watch?v=X4EUwTwZ110&ab_channel=TheEngineeringMindset

- What is a MOSFET:

https://www.youtube.com/watch?v=DLd5dUychY8&ab_channel=ElectricalElectronicsApplications

A coil with current acts as a magnet



Relay principle: 1. Coil, 2. Armature, 3. Moving contact
Source: Wikimedia Commons

Q: For how long can Energizer 522 (~500 mAh) 9 V battery operate a relay (JQX-15F) which draws 100 mA?

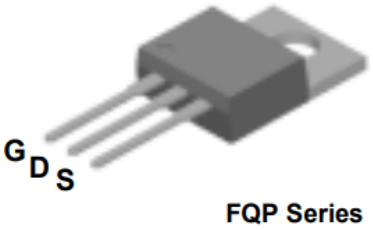
A. About 1.5 hours
B. About 3 hours
C. About 5 hours
D. About 9 hours
E. About 45 hours

The Transistor

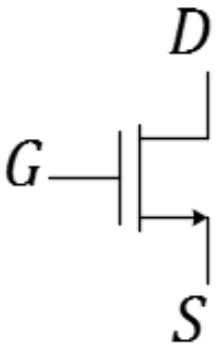
- The transistor changed the world!
- Prior to the transistor, we had the vacuum tube:
  - Large
  - Hot
  - Low efficiency
  - High failure rate
  - Could not be integrated into an IC

The MOSFET (a transistor)

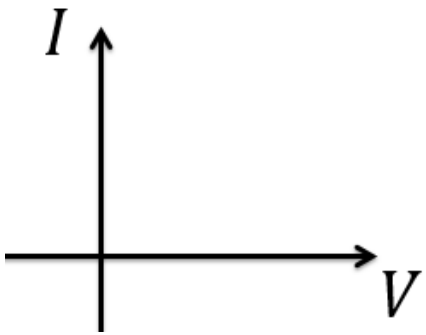
Physical



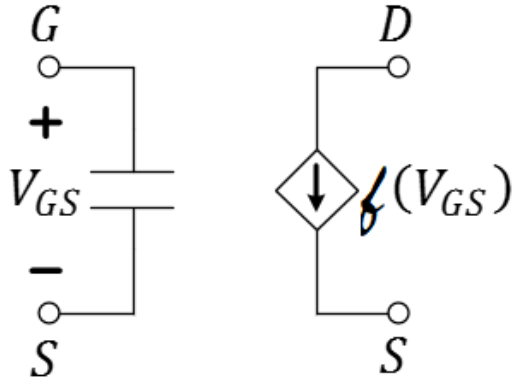
Circuit schematic



IV Plot (for fixed V_{GS})



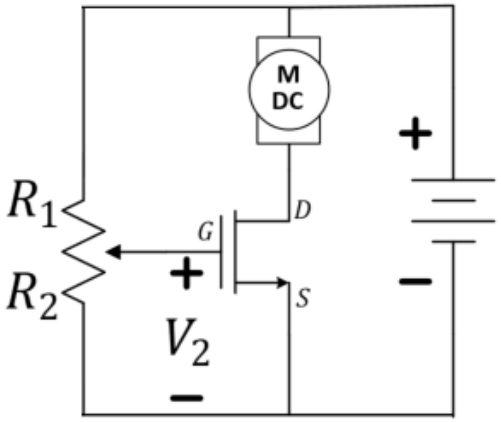
Linear Model



Interpretation: Terminals D and S may be considered to contain a current source whose current is controlled by V_{GS}. The controlling side is generally much lower power than the current source side making the controller easier to design and lower cost.

The MOSFET In Practice

In lab, we will use the MOSFET as an efficient method of motor control…



L5 Learning Objectives

a. Compute current/voltage rating for a resistor based on its power rating

b. For a **capacitor**, compute **stored energy**, voltage, charge, and capacitance given any of the two quantities.

c. Compute energy stored in a **battery** and **discharge time**.

d. Identify features of the **Transistor** that make it an improvement over vacuum tubes

e. Describe the **MOSFET** and a simple model for it

Lecture 6: Kirchhoff's Laws in Circuits

- Kirchhoff's Current Law (**KCL**) – Conservation of Charge
- Kirchhoff's Voltage Law (**KVL**) – Conservation of Energy
- Solving Circuits with KCL, KVL, and Ohm's Law
- Power Conservation in Circuits

Kirchhoff's Current Law

Current in = Current out

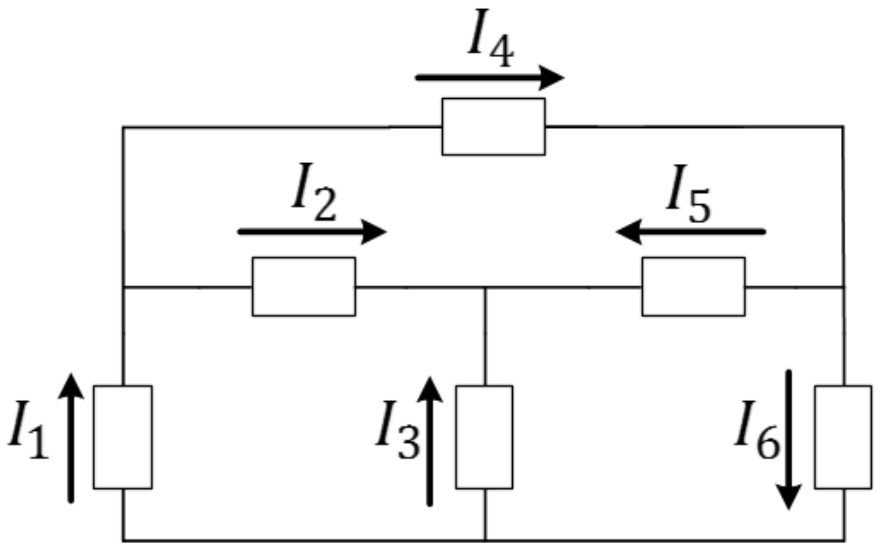
Conservation of charge!

(What goes in must come out, or…
…the total coming in is zero)

Image source: MONGABAY.COM

$$Through\ a\ closed\ surface\ (balloon), \sum_{k=1}^{N} I_k = 0\ where\ I_k\ are\ the\ currents\ flowing\ in\ (alt.out)\ of\ the\ balloon.$$

KCL equations are often used at *nodes*, but can also be used for a *sub-circuit*



Q: Which of the equations is NOT a correct application of KCL?

A. $I_1 = I_2 + I_4$
B. $I_4 = I_5 + I_6$
C. $I_1 + I_3 = I_6$
D. $I_3 + I_5 = I_2$
E. $I_6 - I_4 = I_3 + I_2$

Kirchhoff's Voltage Law

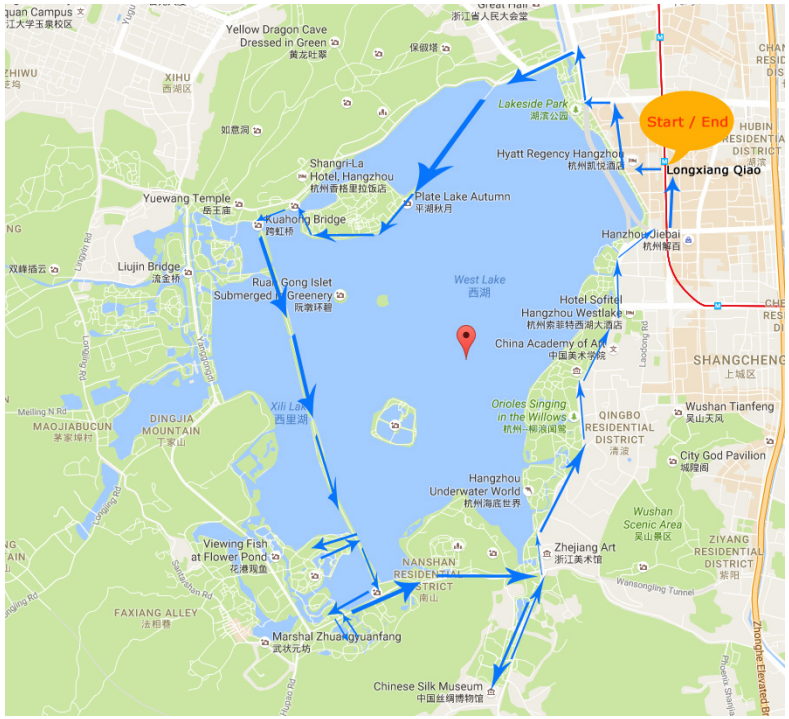
The sum of all voltages around any closed path (loop) in a circuit equals zero

Conservation of Energy!

With voltage, what goes up, must come down

$$Around\ a\ closed\ loop\ (path) \sum_{k=1}^{M} V_k = 0\ \ where\ V_k\ are\ the\ voltages\ measured\ CW\,(alt.CCW)\ in\ the\ loop.$$

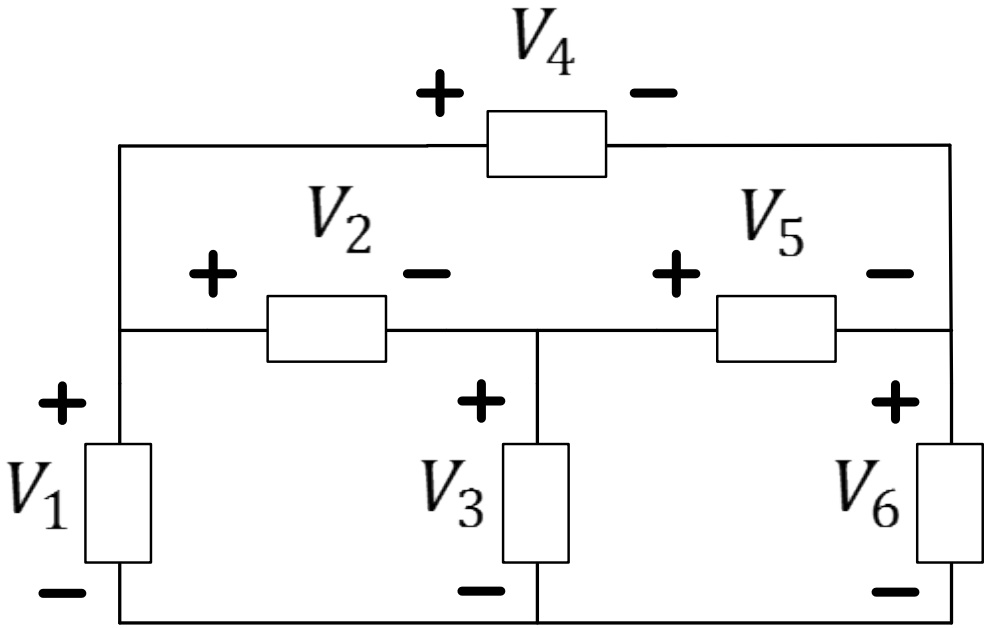
KVL and Elevation Analogy



One can add up elevation changes as we go in a complete loop from point A back to point A.

The result should be zero, independent of the path taken.

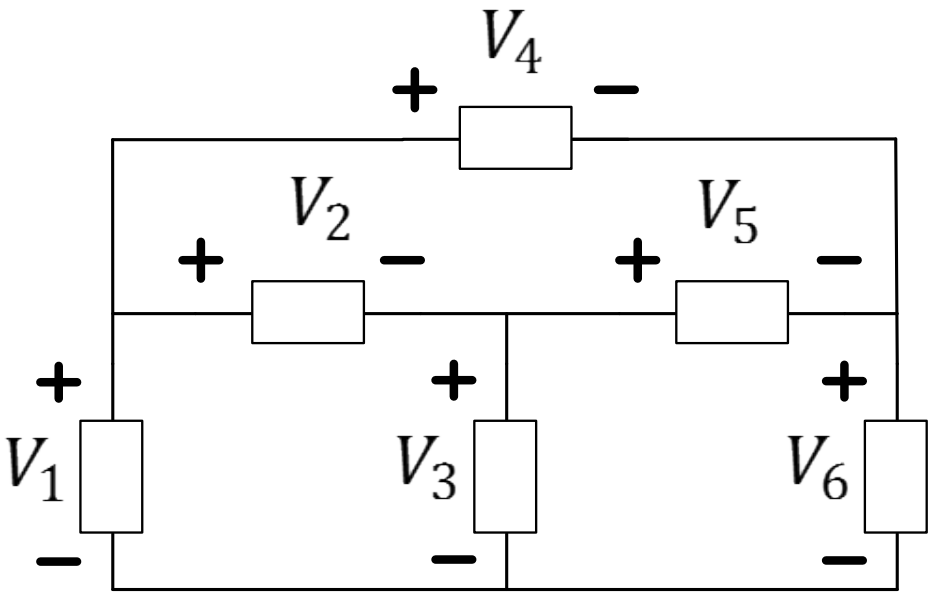
Keeping track of voltage drop *polarity* is important in writing correct KVL equations.



Q: Which of the equations is NOT a correct application of KVL?

A. $V_1 - V_2 - V_3 = 0$
B. $V_1 = V_2 + V_5 + V_6$
C. $V_1 - V_4 = V_6$
D. $V_3 + V_2 = V_1$
E. $V_3 + V_5 = V_6$

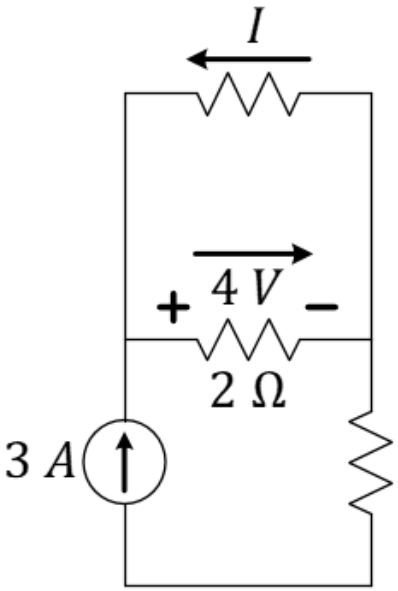
Missing voltages can be obtained using KVL.



Q: What are the values of the voltages V_1, V_2 and V_6 if $V_3 = 2\ V, V_4 = 6\ V, V_5 = 1\ V$?

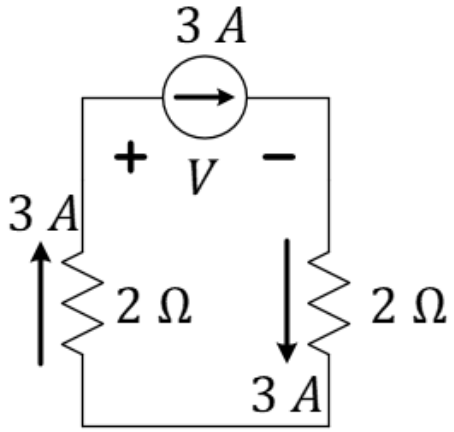
Examples

Q: Find the value of I.



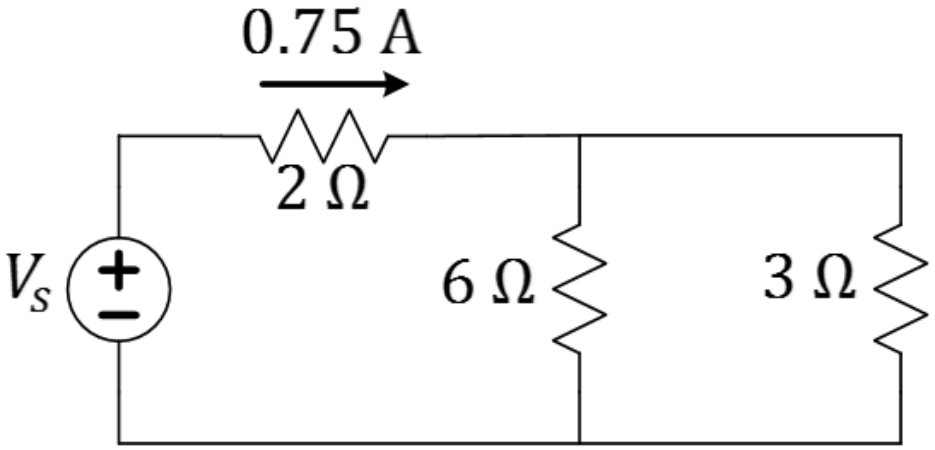
A. $-3\ A$
B. $-2\ A$
C. $-1\ A$
D. $1\ A$
E. $2\ A$

Q: Find the value of V.



A. $-12\ V$
B. $-6\ V$
C. $-3\ V$
D. $6\ V$
E. $12\ V$

Circuits solved with Ohm's + KCL + KVL



Q: What is the value of the source voltage?

Q: How much power is the source supplying?

Q: How much power is each resistance consuming?

L6 Learning Objectives

a. Identify and label circuit nodes; identify circuit loops

b. Write node equation for currents based on KCL

c. Write loop equations for voltages based on KVL

d. Solve simple circuits with KCL, KVL, and Ohm's Law

e. Calculate power in circuit elements, verify conservation