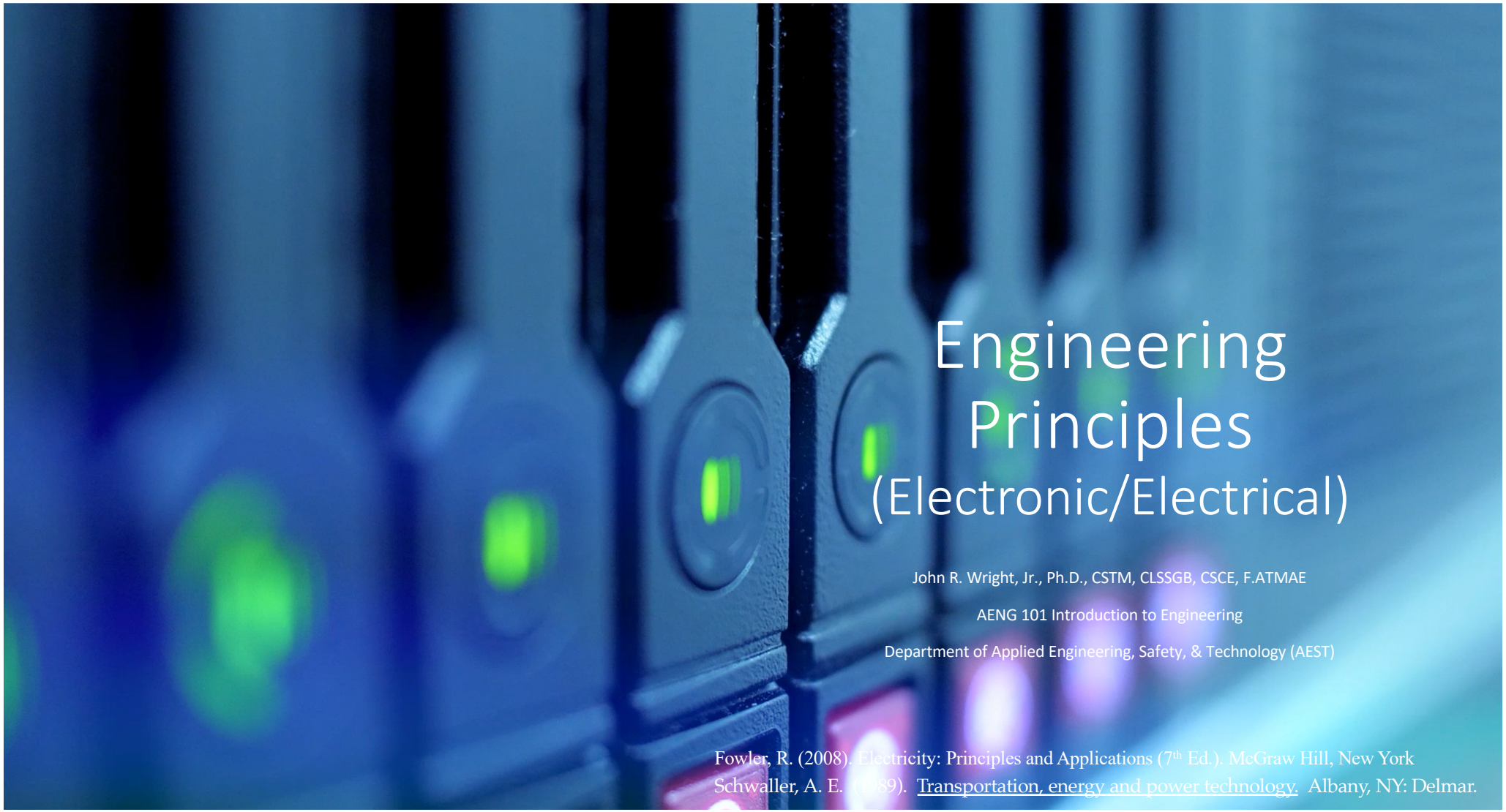


Engineering Principles (Electronic/Electrical)

John R. Wright, Jr., Ph.D., CSTM, CLSSGB, CSCE, F.ATMAE

AENG 101 Introduction to Engineering

Department of Applied Engineering, Safety, & Technology (AEST)

Fowler, R. (2008). Electricity: Principles and Applications (7th Ed.). McGraw Hill, New York

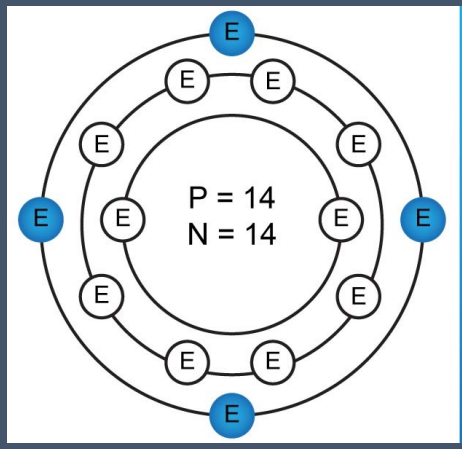
Schwaller, A. E. (1989). Transportation, energy and power technology. Albany, NY: Delmar.

Outline

https://www.europeanscientist.com/en/features/the-belgian-electricity-industry-in-chaos/

- Chemistry of Electricity
- DC Power
- Flow of Electrons
- Amperage, Voltage & Resistance
- Simple Circuits (Series, Parallel & Series-Parallel)
- Magnetism and AC Power
- Integrated Circuits (Basic Digital Gates)

Chemistry of Electricity

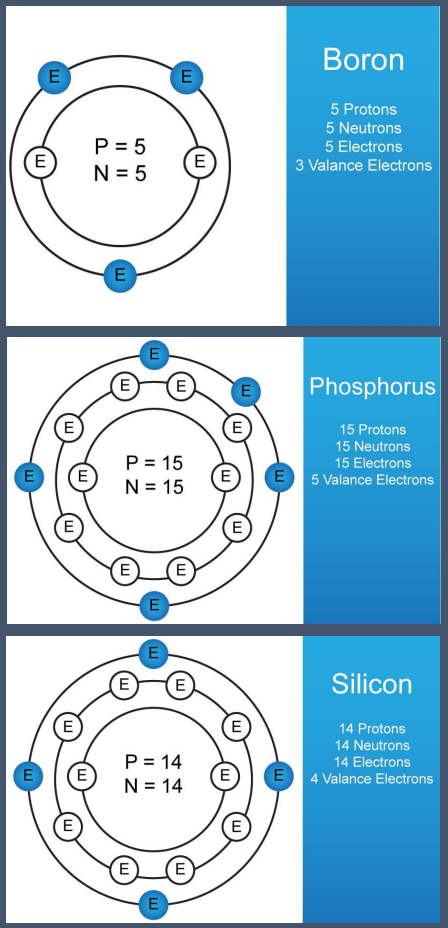


http://www.bysolar.com/solar-energy/how-solar-cells-work/

- Atomic Structure
  - Electrons are -
  - Protons are +
  - Neutrons have no charge
    - An Atom in its natural state should have a net charge of zero
    - The attractive force between the protons and the electrons allow the electrons to maintain an orbit around the nucleus
- Valence Ring/Shell
  - Electrons in the outermost shell
  - They are the atomic particles that are involved in chemical reactions and electrical currents
  - The further out the last shell is from the nucleus, the smaller the attractive force is to maintain orbit

Chemistry of Electricity

- Conductors
  - Very little resistance
  - Copper, aluminum, silver, and gold
  - 3 or fewer valence electrons
- Insulators
  - Very high resistance
  - Paper, wood, plastics, rubber, glass, and mica
  - 5 or more valance electrons
- Semiconductors
  - 4 valance electrons
  - Silicon (Si) and Germanium (Ge) are commonly used
  - Neither a good conductor or a good insulator
  - They allow some current to flow, but have a good bit of resistance
  - ICs are semiconductors

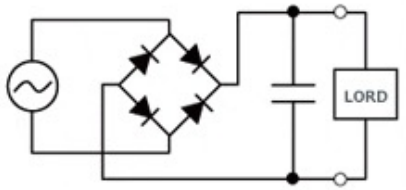
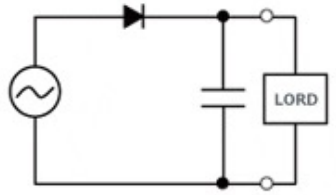
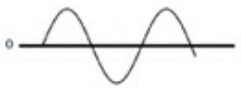
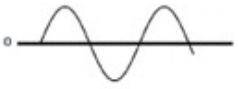


http://www.bysolar.com/solar-energy/how-solar-cells-work/

DC Power

- DC = Direct Current
- May be created with two common methods
  - Chemical (Batteries)
  - Rectification
    - A method of changing AC Power (Alternating Current) to DC Power
    - Use Diodes and capacitors (one-way devices)
    - This is studied more in AENG 262 Semiconductor Electronics when we design power supplies

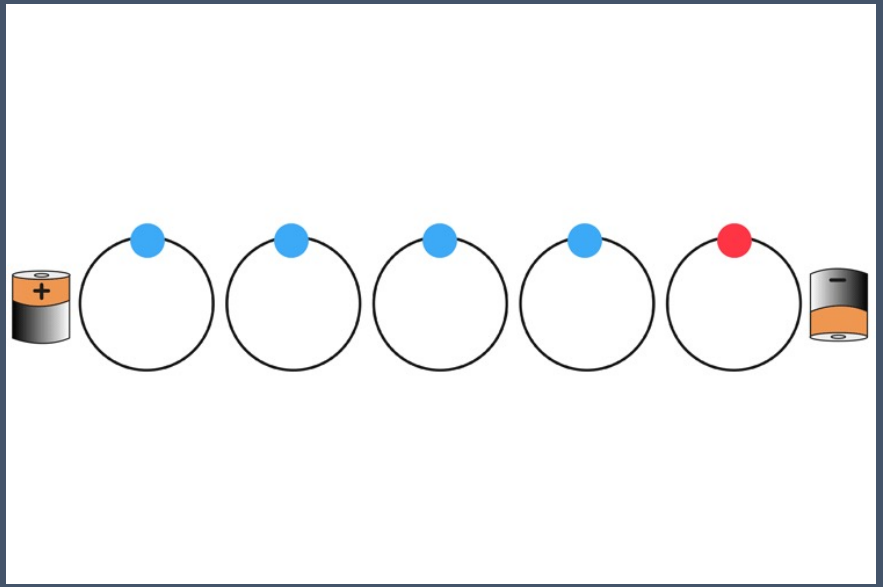
https://www.dccomics.com/blog/2019/04/18/prep-your-playlist-the-music-of-dc-comics-volume-2-is-coming-soon

	Full-Wave Rectification	Half-Wave Rectification
Circuit Configuration		
Input Voltage Waveform		
Voltage Waveform After Rectification		
Voltage Waveform After Rectification Smoothing		

https://www.rohm.com/electronics-basics/ac-dc/rectification

Flow of Electrons

- Electricity is defined as the movement of electrons from atom to atom. This can happen only in a conductive material.
- Electron Theory
  - Flow is from - to +
  - Flow Theory focusses on the electrons actual movement
- Conventional Theory
  - Flow is from + to –
  - Flow Theory focusses on the positive charge flow (holes left behind as electrons move)



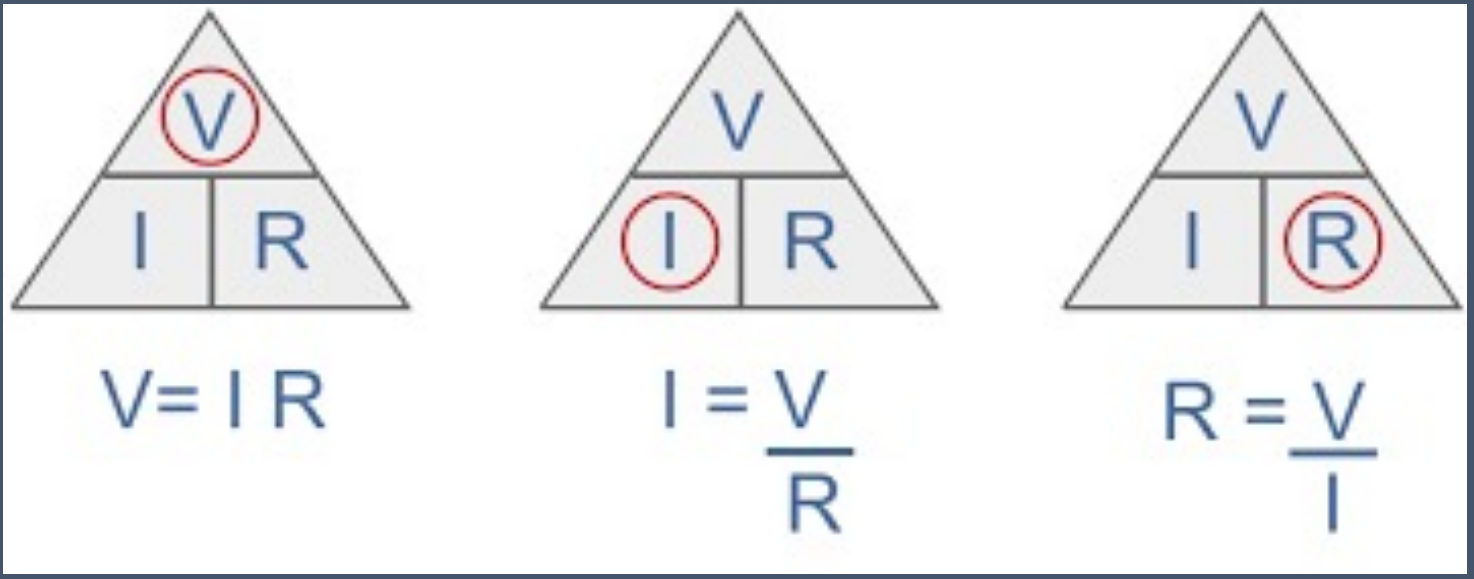
https://mammothmemory.net/physics/electricity/which-way-does-electricity-flow/path-of-a-single-electron.html

Amperage, Voltage & Resistance

- Amperage *(measured in current, I)*
  - Defined as “the amount of electrons flowing from a negative point to a positive point in a given time period”
- Voltage *(measured in volts, V or E)*
  - Defined as “the push or force used to move the
- Resistance *(measured in ohms, Ω)*
  - Defined as “the opposition to current flow”

https://www.fluke.com/en-us/product/electrical-testing/digital-multimeters/fluke-117

Ohm’s Law

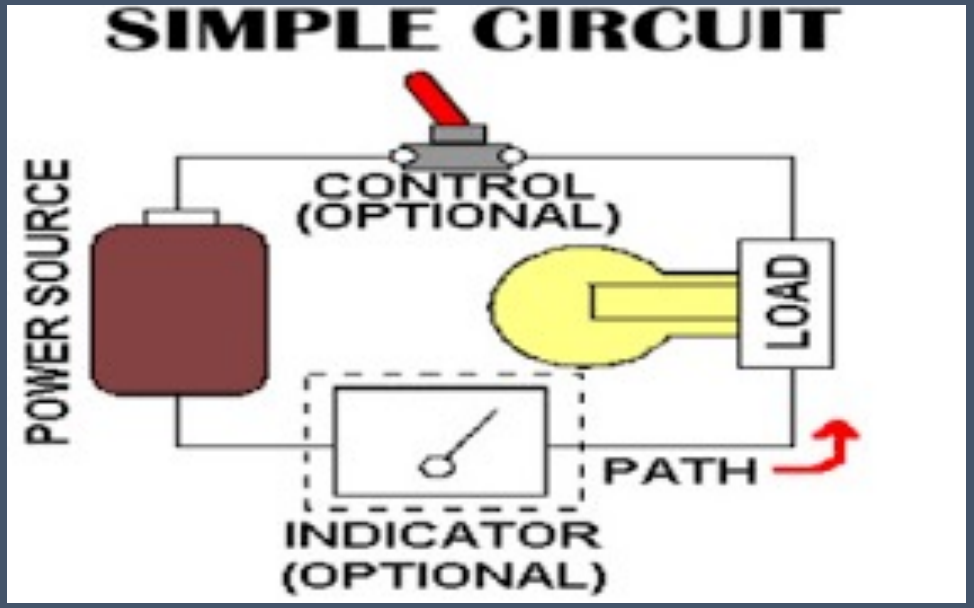


https://www.electronics-notes.com/articles/basic_concepts/resistance/what-is-ohms-law-formula-equation.php

https://en.wikipedia.org/wiki/Georg_Ohm

Simple Circuits

- Series
  - A circuit that contains 2 or more loads but only 1 path for current to flow
- Parallel
  - A circuit which has more than 1 path for current to flow
- Series-Parallel
  - A combination of a Series circuit and a Parallel circuit



https://www.edgefx.in/simple-electronic-circuits-for-students/

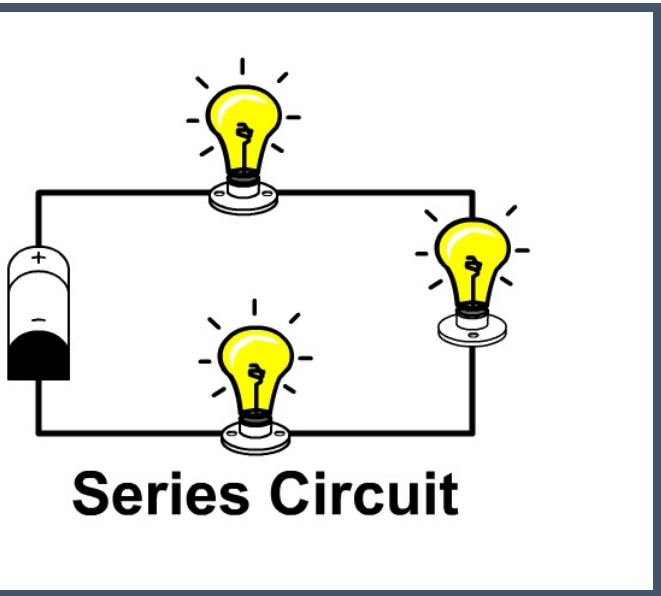
Series Circuits

- $I_T = I_{R1} = I_{R2} = I_{R3}$ = etc.
- $R_T = R_1 + R_2 + R_3$ + etc.
- $V_T = V_{R1} + V_{R2} + V_{R3}$ + etc.
  - Individual voltages are directly proportional to individual resistances

•**Kirchhoff's current law** (1st Law) states that the current flowing into a node (or a junction) must be equal to the current flowing out of it. This is a consequence of charge conservation.

•**Kirchhoff's voltage law** (2nd Law) states that in any complete loop within a circuit, the sum of all voltages across components which supply electrical energy (such as cells or generators) must equal the sum of all voltages across the other components in the same loop. This law is a consequence of both charge conservation and the conservation of energy.

https://isaacphysics.org/concepts/cp_kirchhoffs_laws



https://stickmanphysics.com/stickman-physics-home/unit-8-current-and-circuits/series-circuit/

Example Series Circuit

Parallel Circuits

- $I_T = I_{R1} + I_{R2} + I_{R3}$ + etc.
- $R_T = 1 / ((1/R_1) + (1/R_2) + (1/R_3)_{...})$
  - The word is Reciprocal!
- $V_T = V_{R1} = V_{R2} = V_{R3}$ = etc.

•**Kirchhoff's current law** (1st Law) states that the current flowing into a node (or a junction) must be equal to the current flowing out of it. This is a consequence of charge conservation.

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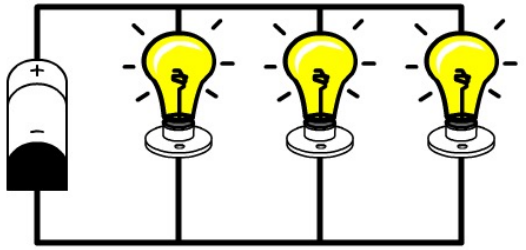


Parallel Circuit

https://stickmanphysics.com/stickman-physics-home/unit-8-current-and-circuits/series-circuit/

Example Parallel Circuit

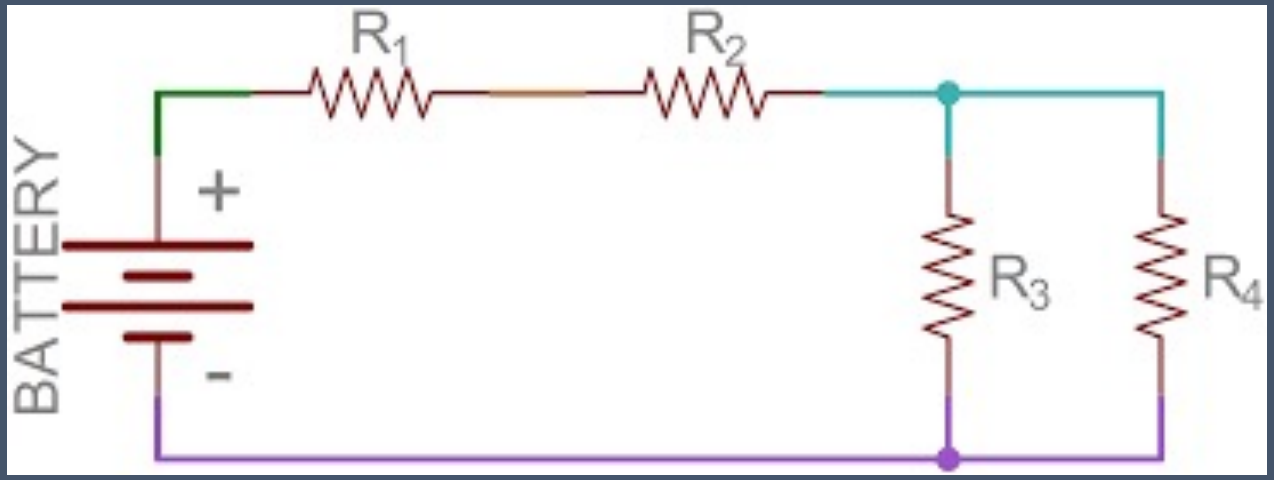
Series-Parallel Circuits

- Some features from both series and parallel circuit exist
- Use Ohm's Law
- and the 2 Kirchhoff's laws
  - if solving for a total value such as I_T, V_T, or R_T:
    - Try and transform the parallel parts into a singular resistor and then solve thru series formulas
    - These are called Equivalent Circuits

•**Kirchhoff's current law** (1st Law) states that the current flowing into a node (or a junction) must be equal to the current flowing out of it. This is a consequence of charge conservation.

•**Kirchhoff's voltage law** (2nd Law) states that in any complete loop within a circuit, the sum of all voltages across components which supply electrical energy (such as cells or generators) must equal the sum of all voltages across the other components in the same loop. This law is a consequence of both charge conservation and the conservation of energy.

https://isaacphysics.org/concepts/cp_kirchhoffs_laws



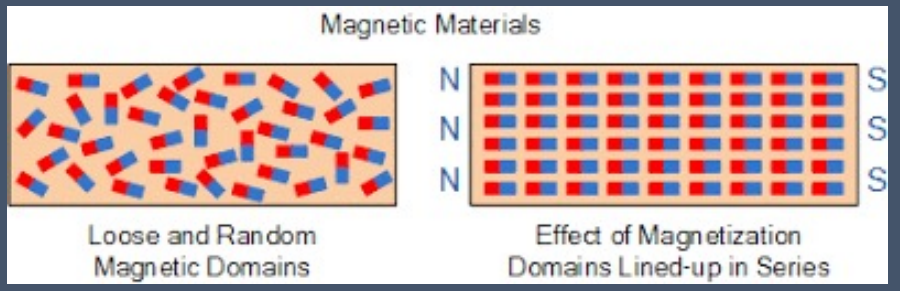
https://learn.sparkfun.com/tutorials/series-and-parallel-circuits/series-circuits

Example Series-Parallel Circuit

Magnetism Basics

- Magnetism - a force that acts on some materials but not on other materials
- Magnets - are physical devises which possess this force
    - Lodestone (Fe Compound) - natural magnet
    - Neodidium - Used in some EV motors
- Electro-magnets – devices that become magnetized with the addition of an electric field
- Polarity of a Magnet:
    - N and S poles (flux flow is from N to S)
        - Like poles repel
        - Unlike poles attract
- Domains
    - Are minute sections in a bar where the atoms line up to produce a magnetic field
        - Must be lined up in same direction to be a magnet

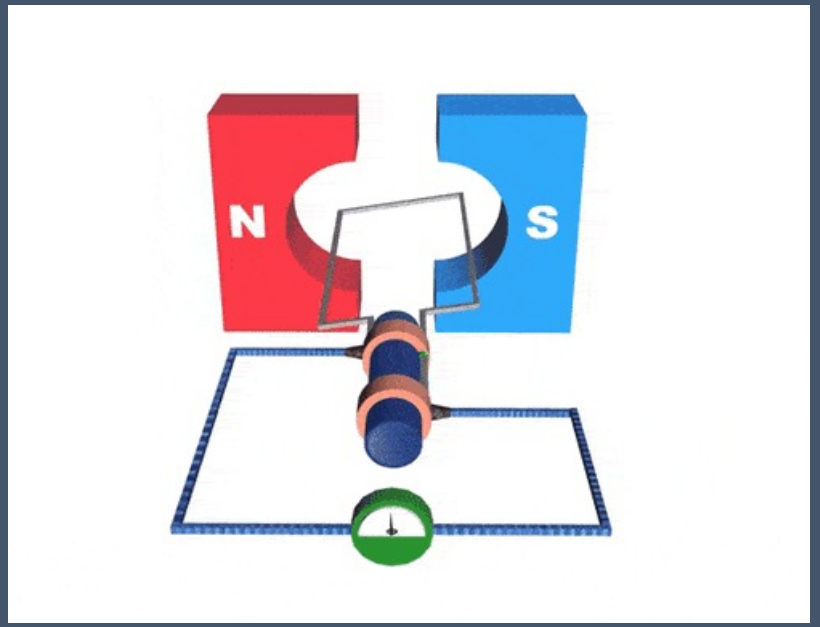
https://www.stanfordmagnets.com/how-are-the-magnets-made.html



https://www.electronics-tutorials.ws/electromagnetism/magnetism.html

Electromagnetic Induction (How we make AC Power)

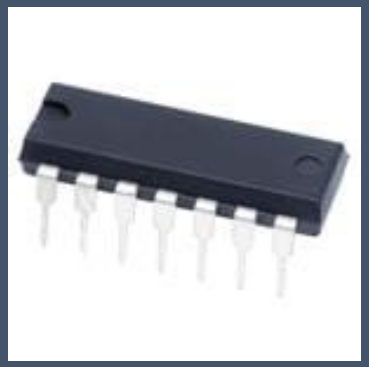
- When you take an conductor pass it through a magnetic field, a voltage is induced in the the wire (conductor)
  - perpendicular to lines of flux = greatest voltage
  - parallel to lines of flux = zero voltage
  - rotating the conductor 360^{o} creates AC voltage
- This subject matter will be covered more extensively in AENG 261 Electronic Systems

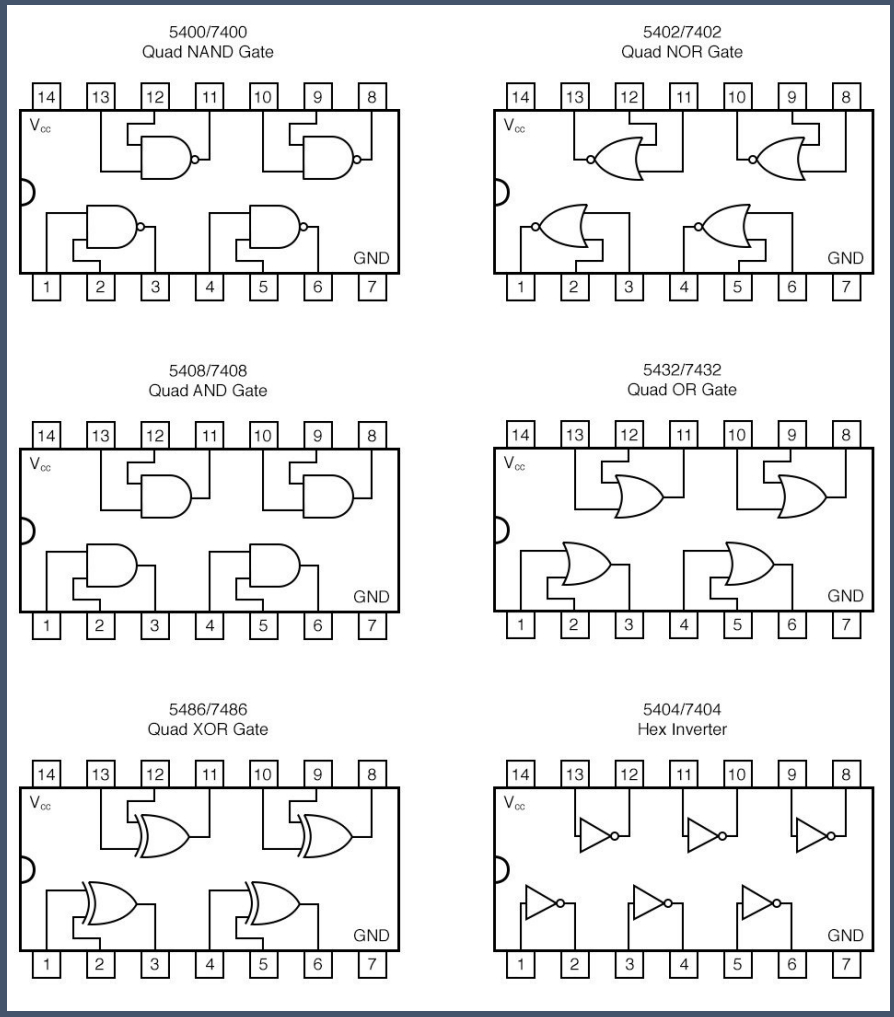


https://quizizz.com/admin/quiz/5ebbca069f5fb3001bc5a201/electromagnetic-induction-review

Integrated Circuits (Basic Gates)

- AND Gate
- OR Gate
- Inverter (Not) Gate
- NAND
- NOR
- XOR





http://www.learningelectronics.net/vol_4/chpt_3/11.html

Truth Tables and Boolean Expressions

Truth Tables and Boolean Expressions

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