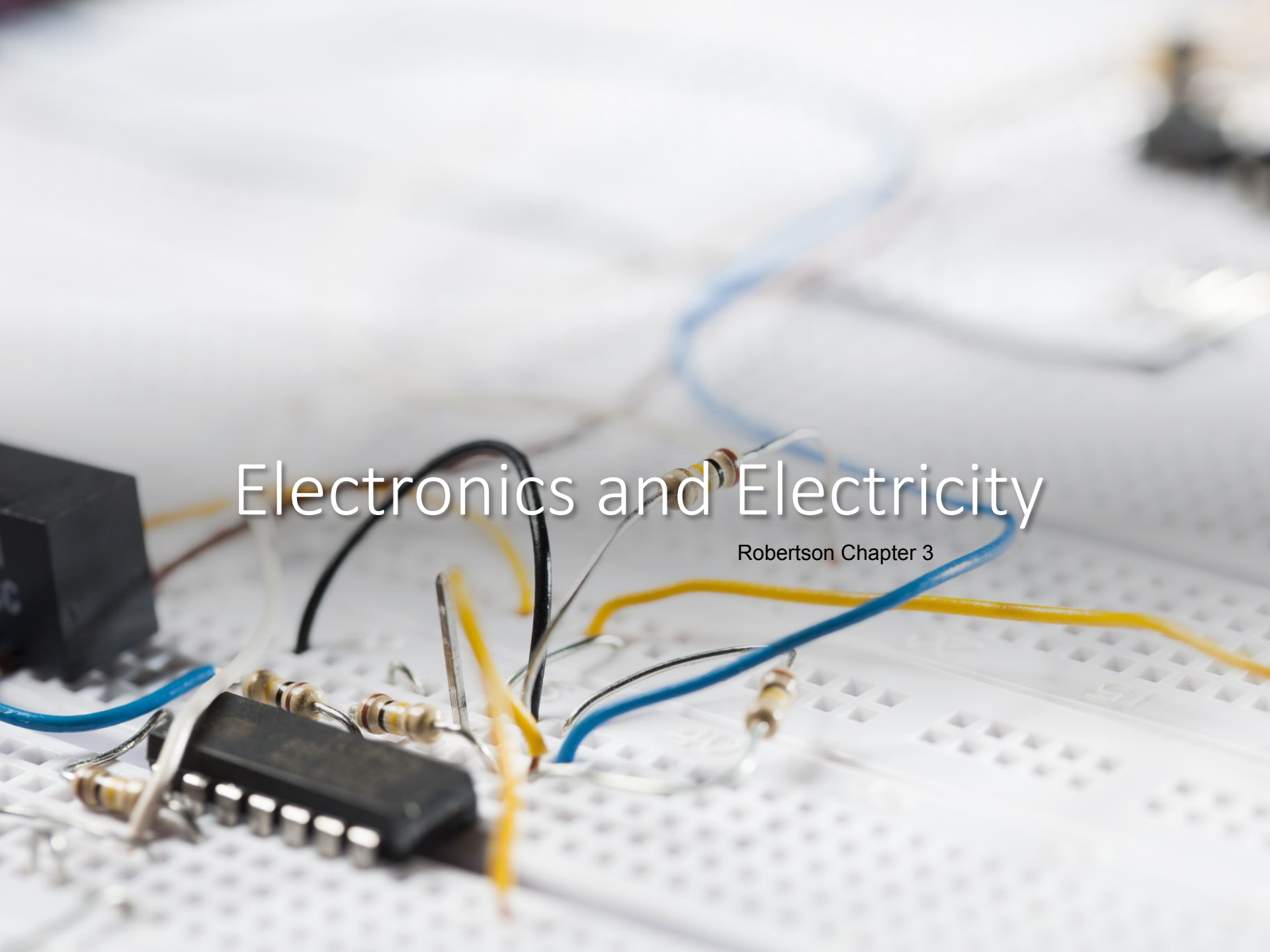


Electronics and Electricity

Robertson Chapter 3

Forms of Electricity

- Static electricity = Electrical energy created by interaction of charged objects in close proximity
- Electrochemistry = Conversion of chemical energy into charge
  - Form of electricity generated by batteries
- Photoelectricity = Conversion of light into electricity
- Piezoelectric effect = Arises from mechanical strain put on certain types of crystals
  - Used commonly in medical sensing equipment

Forms of Electricity

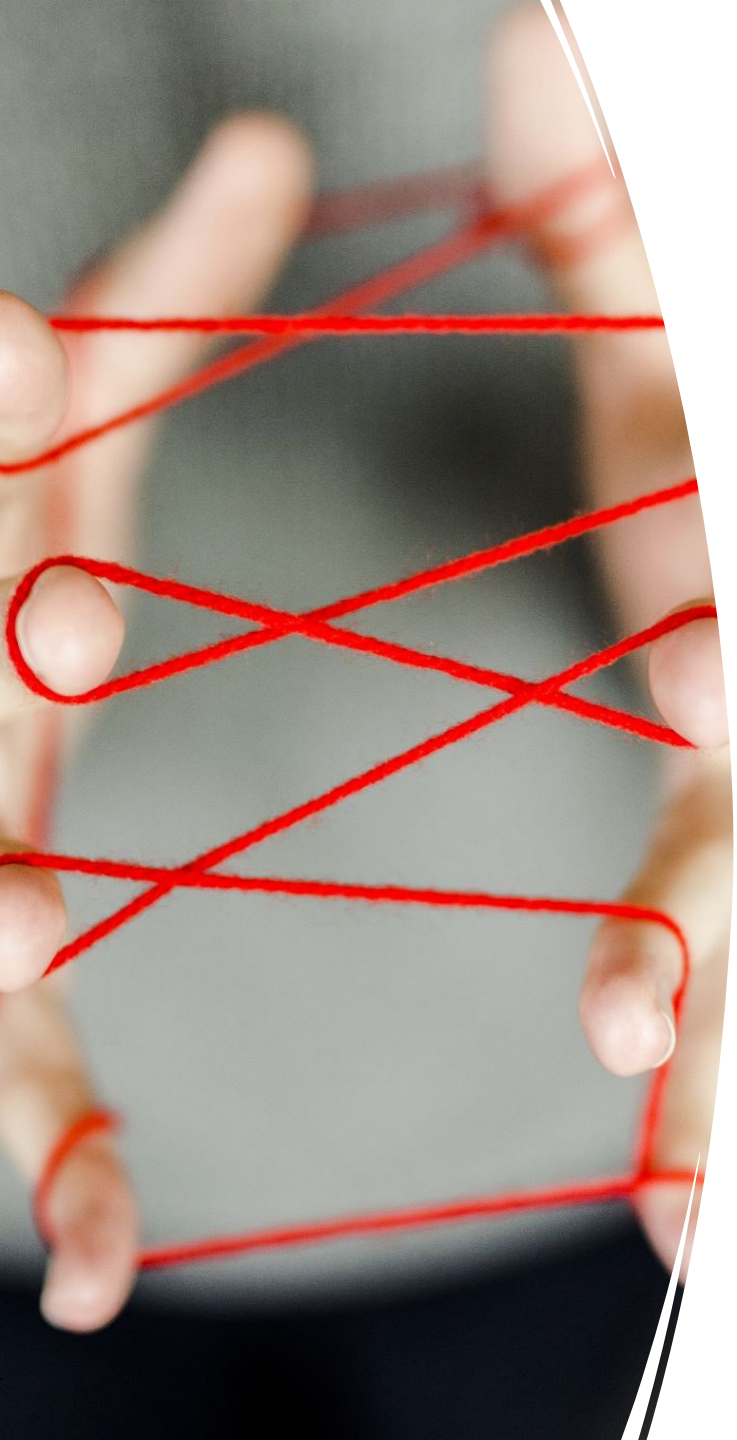
Thermoelectric effect = Conversion of temperature differences into electricity

Nuclear electricity = Conversion of energy that binds nucleus of atoms together into electrical charge, either by breaking atom apart (fission) or combining atoms together (fusion)

Electromagnetic induction = Uses motion of magnets in close proximity to wires to convert mechanical energy into electricity

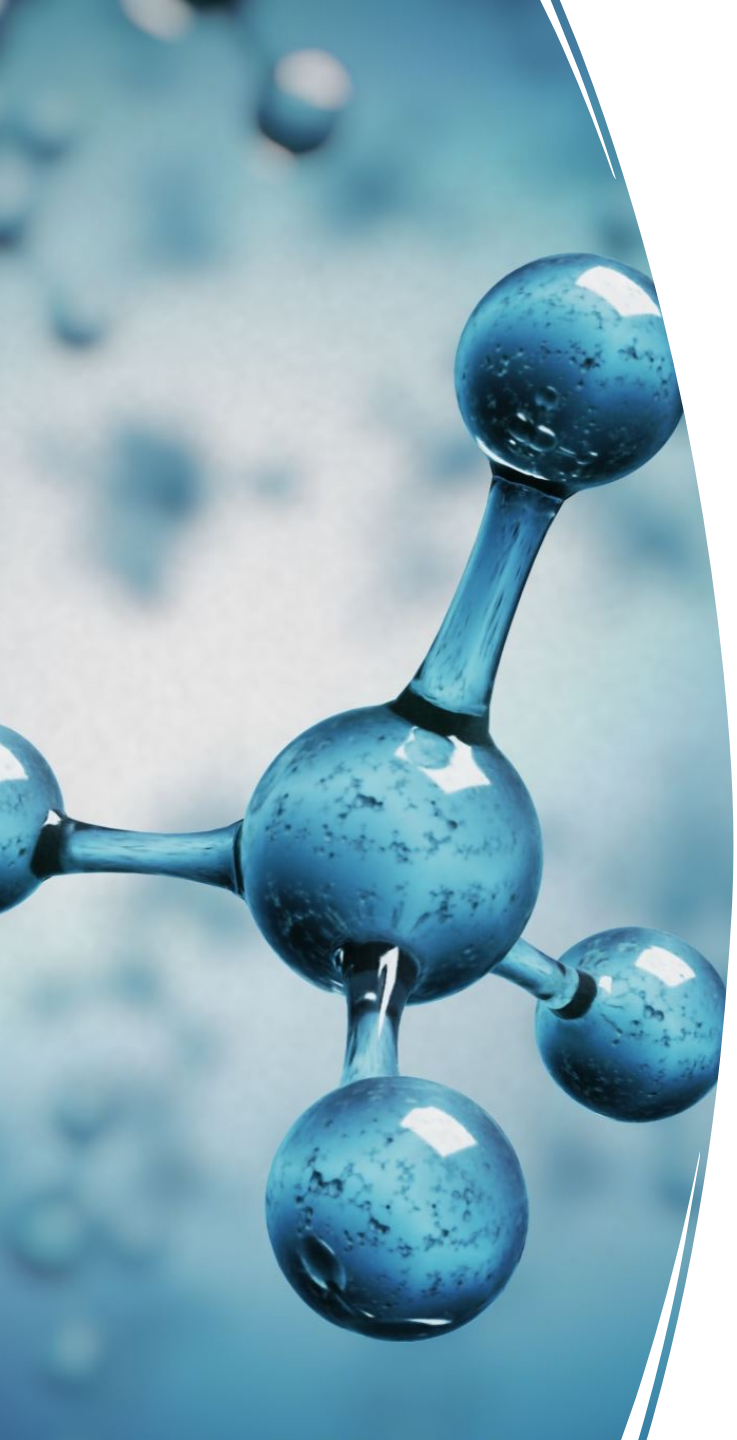
Static Electricity

- First observed form of electrical activity
  - Seen in lightning, shock between fingertip and doorknob, static cling in clothes
- 2 types of charges
  - Negative charges result from build-up of electrons
  - Positive charges result from build-up of protons
- Net charge = Equal electrons and protons



Static Electricity

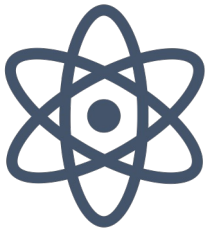
- Like charges repel each other, while opposite charges pull toward each other
- Voltage = Potential difference in energy between charges
  - Symbol = V
- Coulomb's Law = How close the objects need to be for an interaction is based on strength of the charges
  - The greater the charges, the greater the attraction or repulsion between the 2 objects
  - The greater the distance between objects, the weaker the attraction or repulsion between objects



Electricity Principles

- Charge is always conserved
  - Cannot be lost or created but can be rearranged
- Electrochemical electricity
  - Cells in body generate electrical energy by controlling quantity of positively charged sodium ions and negatively charged potassium ions inside and outside cell membrane

Electricity Principles



Photoelectricity

Photon = Particle in a light wave

- Massless and neutral charge
- When absorbed, energy is increased
- The more intense the light, the greater the energy

Thermoelectric Effect

Arises from difference in temperature across a charge-carrying medium

- Change in temperature is measure of change of energy

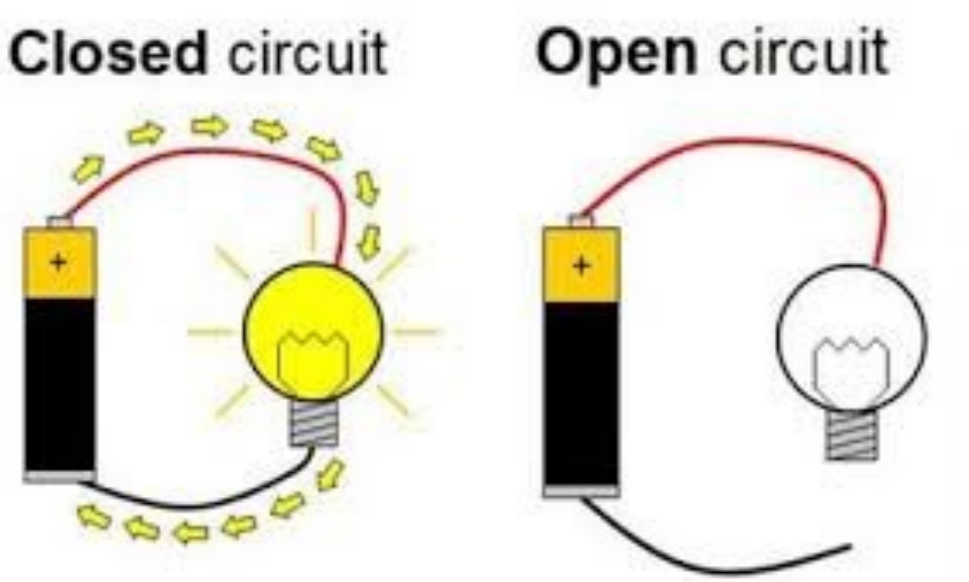
Seeback effect = On unevenly heated surface, free electrons from warm side move to cooler area and create voltage difference

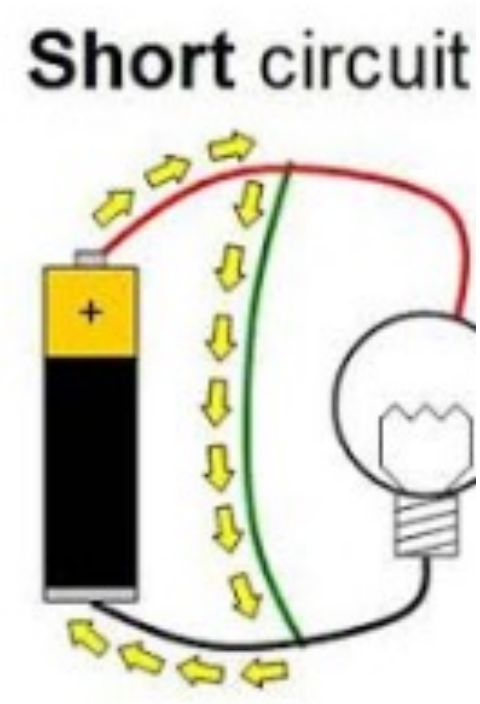
Electricity Principles

- Piezoelectric Effect
  - Comes from deformation of certain types of crystals
    - Deformation generates electrical energy

Electronic Circuits

- Combination of conductive materials and electronic components assembled to perform one or more functions
- Closed circuit = Current pathway is connected
- Open circuit = Current pathway is disrupted





Electronic Circuits

- Special case of closed circuit is short circuit
  - Occurs when loop is closed before current can travel intended path
- Simple and complex circuits are used in PSG

Current Flow

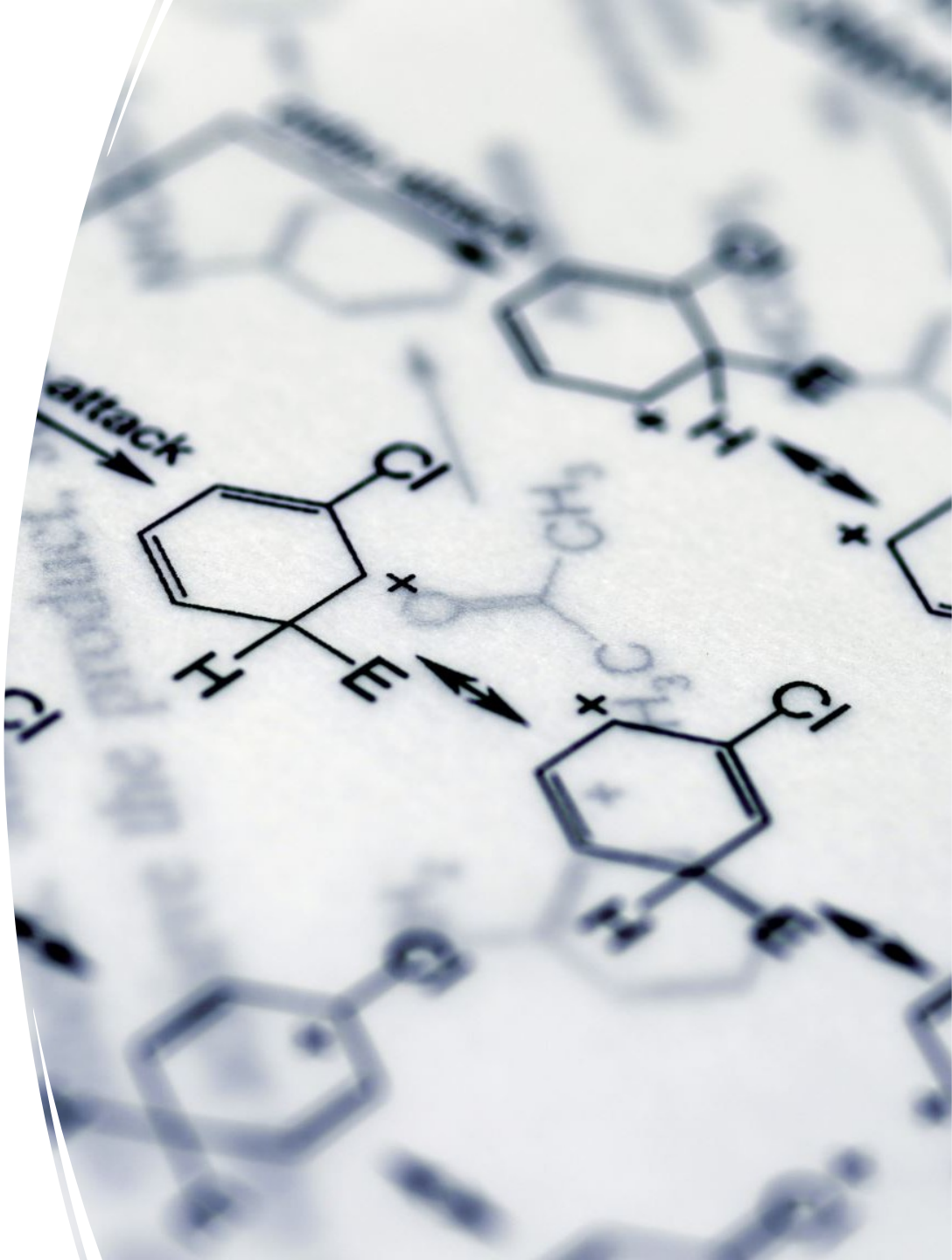
- Motion of charged particles through conductive medium
- In electronics, current is motion of electrons through conductive medium moving from lower voltage to higher voltage
  - Voltage difference = Electromotive force (EMF)
- Direct current (DC) = Voltage potential remains the same across given circuit
  - Electrons flow in single direction in circuit
    - Only one direction of flow
    - Either on or off

Current Flow

- Alternating current (AC) = Constant alternation of positive and negative terminals in circuit
  - Often created by electromagnetic induction
- Hertz (Hz) = Number of rotations in given time frame (frequency)
  - Also known as cycles per second (cps)
  - Standard frequency = 60 Hz
    - Consistent frequency needed for reliable power delivery for AC devices

Current Flow

- Charles Coulomb described relationship of charged particles, distance, and force between them
  - Electron and proton have same value of charge but opposite signs
    - Based on coulomb (C)
- Current (I) is measured in amperes (A)
  - One ampere is equal to one coulomb passing through a point in an electrical circuit in one second



Introduction to Electrical Components

- Conductor = Any material that permits the flow of electrons
  - Metals are often excellent conductors
    - Commonly used metals for electronics:
      - Copper
      - Lead
      - Silver
      - Gold
  - Water is a poor conductor without salt
  - Usually surrounded by insulators
    - Rubber, glass, and plastic

Introduction to Electrical Components

- Resistance = Ability of material to impede the flow of electrons
  - Denoted by R
  - Measured in Ohms
  - Good conductor = poor resistor
    - Poor conductor = good resistor
- Ohm's law: Current (I) = Voltage (V) ÷ Resistance (R)
  - ↑ voltage, ↓ resistance
  - ↑ current, ↑ the effects of shock

Basics of Electricity

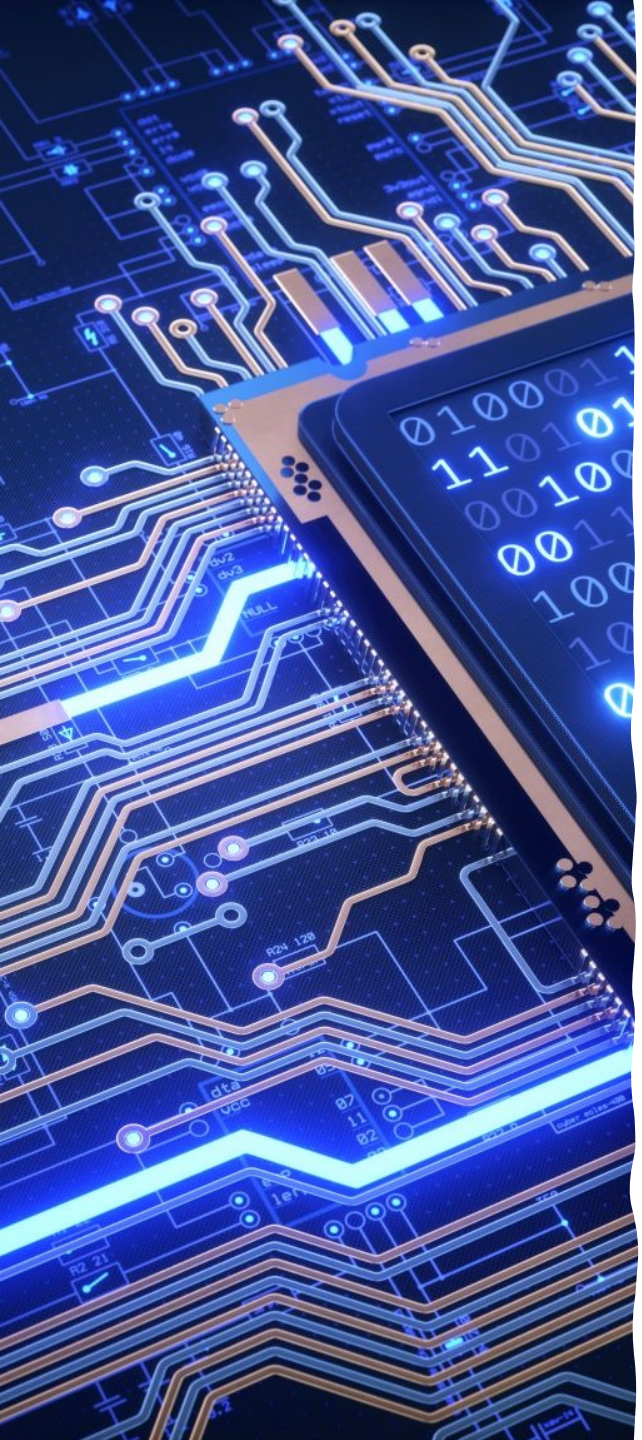
- Current = Flow or movement of electricity
  - Measured in amperes (Amps)
- Voltage = Electrical tension
  - Difference in electrical potential between 2 points
  - Amplitude is measurement
  - Measured in Volts
    - Biologic potentials measured in uV
    - Determined by equation of V = IR

Basics of Electricity

- Voltage Resistance = Degree to which object resists electrical current
  - Measured in Ohms
  - R = V/I
- Goal in PSG = Minimize resistance (impedance) to <5000 Ohms
  - Higher impedance = lower signal quality
- Polarity = + or – nature of electrical signal
- Capacitor – Stores and releases energy in AC circuit

Basics of Electricity

- Leakage current = Current is lost or generated by various properties of the circuit itself
- Ground = Point in electric circuit with assumed potential value of zero
  - Provide intentional and safe paths of departure for current in a circuit
  - In PSG, grounding occurs in at least 2 places:
    - Earth ground wire in 3-wire plug from wall outlet to amplifier
    - Chassis ground on patient's scalp

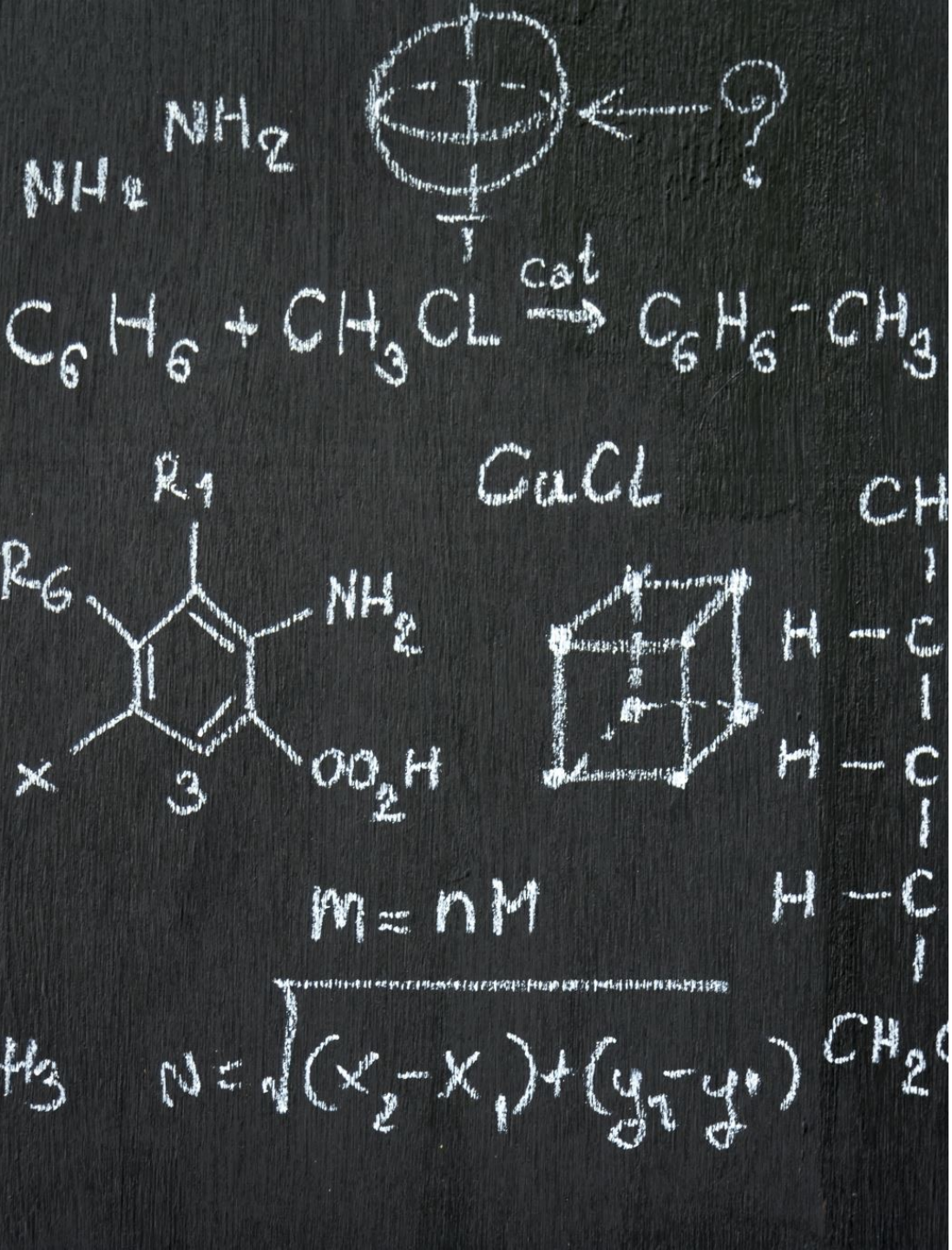


Electrical Grounding

- Ground = Multiple meanings
  - Reference point by which other electrical signals or voltages are measured
  - Common return path for current = physical connection to earth
  - Path of least resistance
  - Common reference for all other electrodes

Basics of Electricity

- 3-hole electrical socket:
  - 1st branch = Earth ground (green wire)
    - Helps ensure any excess current in amplifiers is discharged away from patient
  - 2nd branch = Neutral (white wire)
  - 3rd branch = Hot wire (black wire)
- Power Isolation helps to prevent unwanted noise in a circuit
  - This is why there is a chassis and earth ground on PSG equipment



Electrical Grounding

- If O1 (G1) = 25 uV and M2 (G2) = 40 uV, output would = -15 uV
  - O1 = 25 uV more than ground
  - M2 = 40 uV more than ground
- Ground loop = Using 2 ground leads on patient

Overview of Ancillary Equipment

- Includes any device incorporated into sleep testing in addition to that needed for detecting physiologic sleep
  - Most represent a type of transducer (device that converts 1 form of energy into another)
- Pressure transducers and thermocouples monitor airflow
- Respiratory-induced plethysmography (RIP) and piezoelectric belts monitor respiratory effort
- Piezo devices can monitor snoring
- Oximeter uses mix of photoelectric and plethysmographic devices to detect O2 levels in blood
  - This and capnograph are typically DC devices

Monitoring Devices

- Thermocouples
  - Measures airflow by detecting temperature change using 2 dissimilar metals with different levels of expansion
  - Generates own electricity

Monitoring Devices

- Thermistors
  - Measures airflow by detecting changes in temperature between room air and expired air
  - Signal amplified using wheatstone bridge circuit

Monitoring Devices

- Pressure transducers
  - Measures airflow through cannula
  - Volume of expired air measured
  - Sends signal to DC amplifier

Monitoring Devices

- Oximeters
  - Estimates amount of hemoglobin in blood saturated by O2
    - Oxygenated blood absorbs infrared light more than deoxygenated blood
    - Deoxygenated blood absorbs more red light than oxygenated blood

Monitoring Devices

- Snore sensors and microphones
  - Sensors record vibrations from upper airway
  - Microphones detect noise from snores

Monitoring Devices

- Body Position Sensors
  - DC devices
  - Usually attached to chest belt

Monitoring Devices

- Capnometer
  - Measures CO2 in sample of air by measuring absorption of infrared light

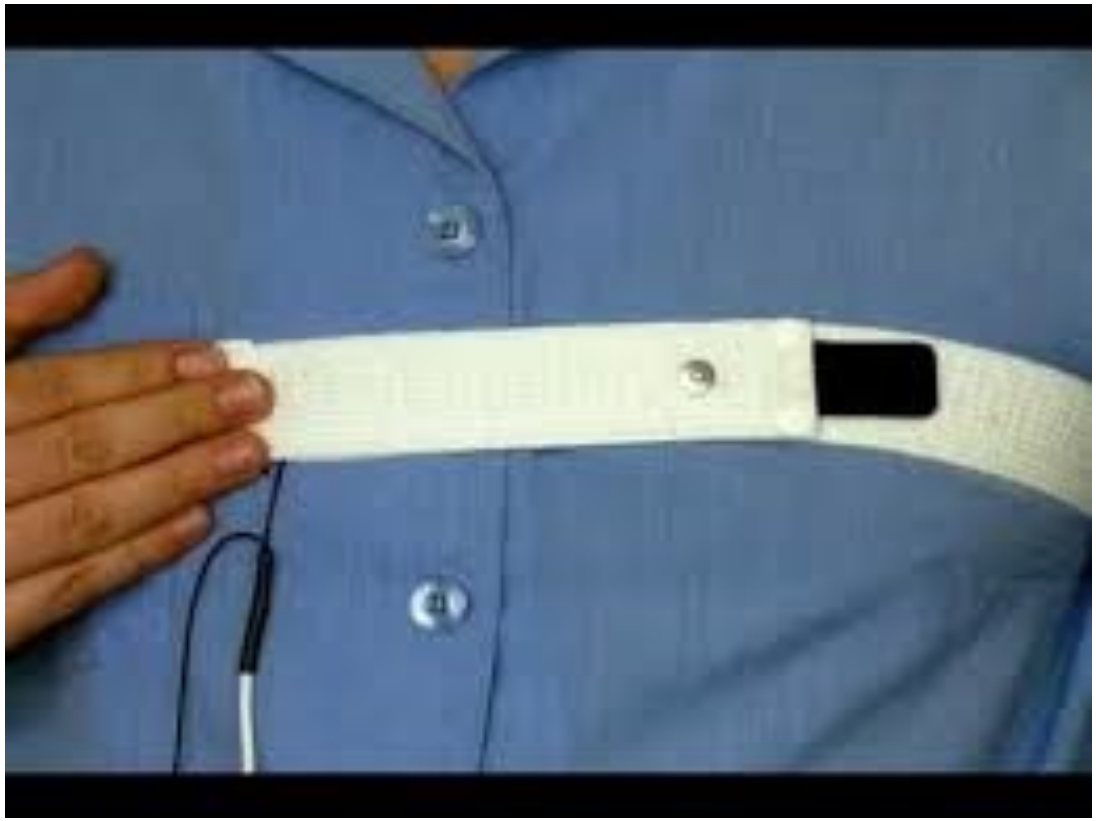
Monitoring Devices

- Capnograph
  - Receives signal from capnometer
  - Measures end-tidal CO2

Monitoring Devices

- Transcutaneous CO2 monitors
  - Measures gases in blood using heated sensor placed on skin
  - Must move sensor due to heat

Monitoring Devices



- Respiratory effort belts
  - Senses resistance from belts stretching

Monitoring Devices

- Respiratory Effort Recording Methods:
  - Inductive Plethysmography
    - Expansion and contraction of chest and abdomen recorded through frequency oscillators distributed to demodulator device
    - Expensive
  - Piezo-electic Crystal Belts
    - Used most frequently
  - Mercury Strain Gauges
    - Dangerous due to potential breakage and leakage

Monitoring Devices

- Cardio-Pneumography
  - 2 chest electrodes
  - Thoracic effort and EKG combined into 1 channel
- Pneumatic Respiration Transducers
  - Uses cuff bladder and pressure transducer system to detect respiratory effort
- Intercostal EMGs
  - EMG activity of intercostal muscles during chest wall expansion

Monitoring Devices

- Esophageal Balloons and Water-filled Catheters
  - Rarely used
  - Inserted through nose into esophagus
- Other Monitoring Devices:
  - pH probes
    - Used to detect esophageal reflux
  - Actigraphs
    - Circadian rhythm monitoring
  - Motion detectors