

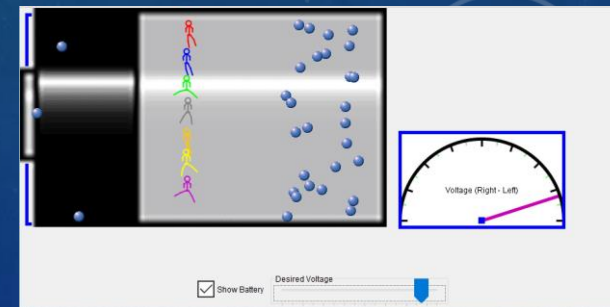
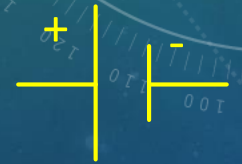


# BATTERIES & POWER SYSTEMS

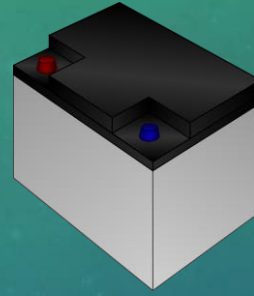
PES 1000 – PHYSICS IN EVERYDAY LIFE

# HOW BATTERIES FUNCTION

- **Batteries** work because they contain **two separated materials that contain oppositely charged ions**.
  - Examples: Nickel Metal Hydride (NiMH), Lithium Ion, Alkaline, Lead/Acid, etc.
- The separated ions have the **potential** to exchange charge and equalize the charge between them, but won't until connected in a circuit.
  - The circuit symbol reflects this separation of charge.
- When connected in a circuit, the **electrons drift** through the ionic material toward the negative terminal of the battery as they seek to pass through the circuit to the positive terminal. The drift is at a **slow rate** so that the battery doesn't discharge all at once.
- **Moving charges through a potential** (voltage) **expends energy**. So the battery eventually runs out of energy as the charges equalize.
- As a battery ages, its **internal resistance** to charge flow **builds up** in the ionic material, eventually counteracting the voltage available to move charge through itself.



# HOW BATTERIES FUNCTION

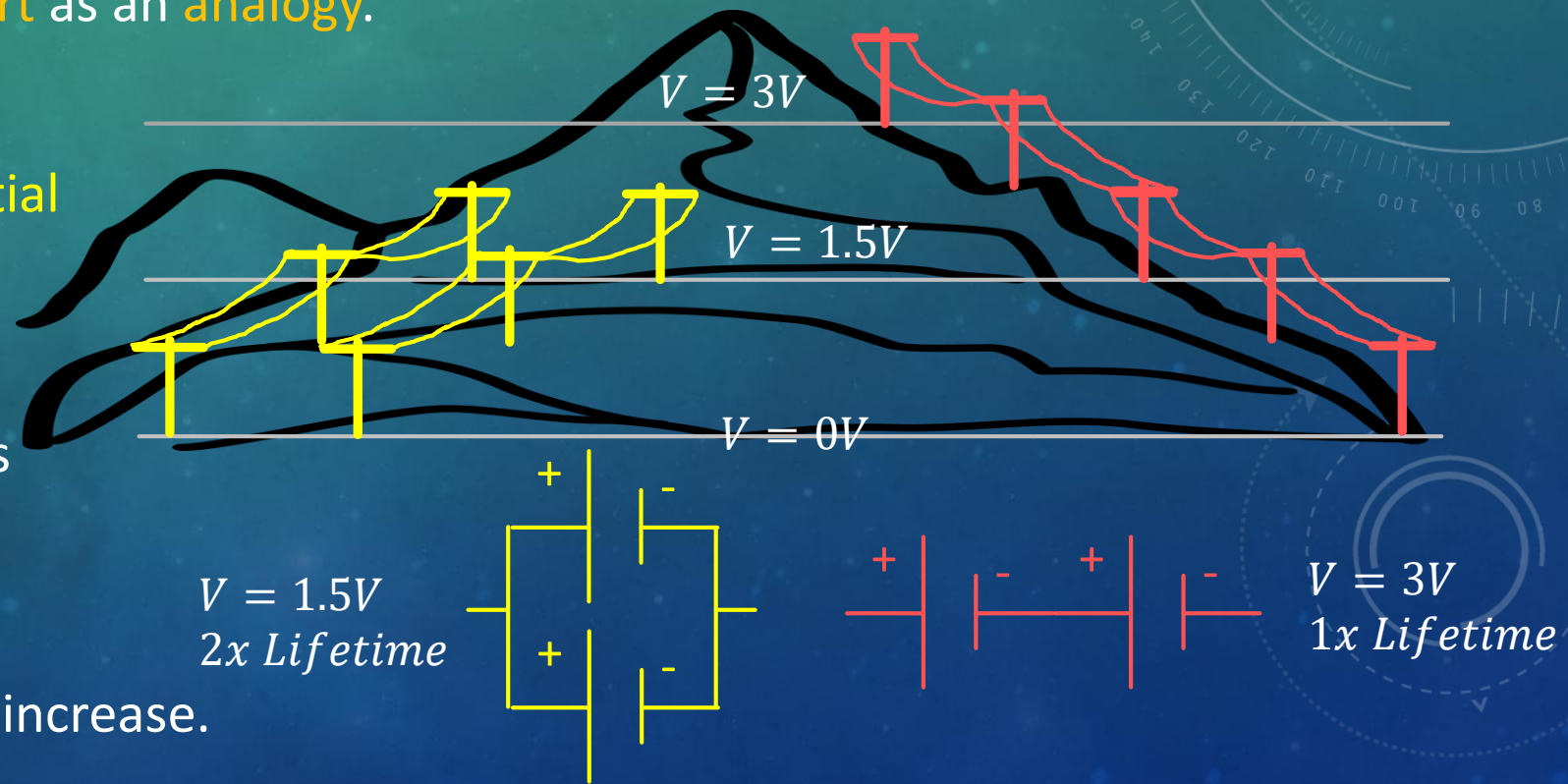


- Some typical voltage sizes:
  - **Car**: 12 V (lead/acid)
  - **Dry cell** : 1.5 V (alkaline, Li-ion, NiMH, etc.)
  - **Rectangular 9V**
- D, C, A, AA, AAA: All have the **same voltage** (1.5 V).
  - The chemistry is the same for these battery types, but the amount of the chemicals differs. AAA has the least, D has the most.
  - Thus they contain **different amounts of energy**.
  - **More energy** means it can move more charge through a 1.5 V difference, so the battery has a **longer life**.
- The 9-V battery is simply six of the 1.5 volt cores connected in series:  $6 \times (1.5 \text{ V}) = 9 \text{ V}$

# BATTERIES IN SERIES & PARALLEL

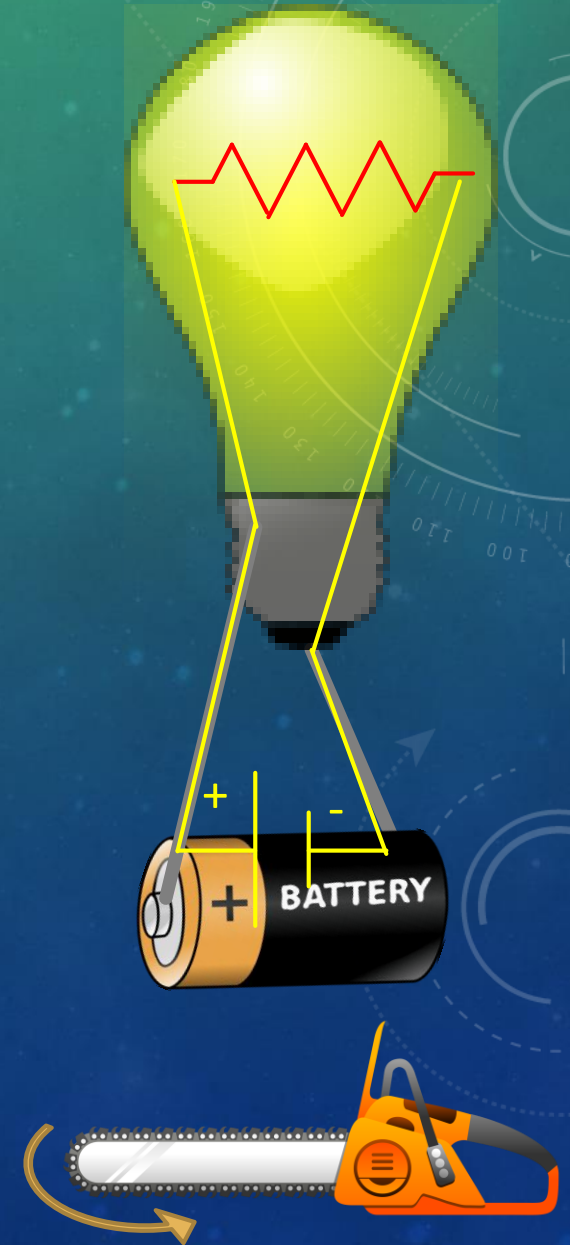
Recall that gravity potential and electric potential are similar. So imagine a **ski resort** as an **analogy**.

- If two ski lifts run in **parallel**:
  - They both raise the **potential** by the **same amount**.
  - Each does **half the work**.
  - For the battery, this means **double the battery life**.
- If two ski lifts run in **series**:
  - They **double the potential** increase.
  - Each does **equal work**.
  - The battery has a **normal lifetime**.



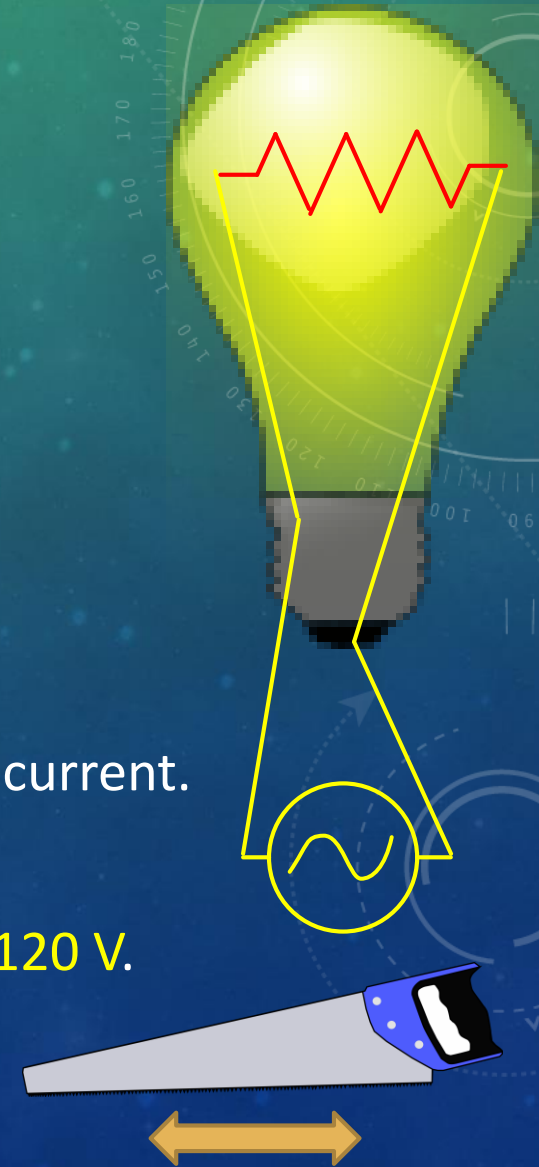
# DIRECT CURRENT (DC) CIRCUITS

- In a **DC circuit**, the current runs in only **one direction**.
- This is typical for a circuit with a **battery**.
- A **flashlight** is a good example of a DC circuit.
  - Another example is the electrical system of a car.
- The **electrons deliver the energy** through the circuit to the filament (resistor). There it is turned into **heat** and **light**.
- This is similar to the way a **chainsaw** works.
  - The teeth deliver energy to the wood by their motion.
  - They cut by moving in only **one direction**.



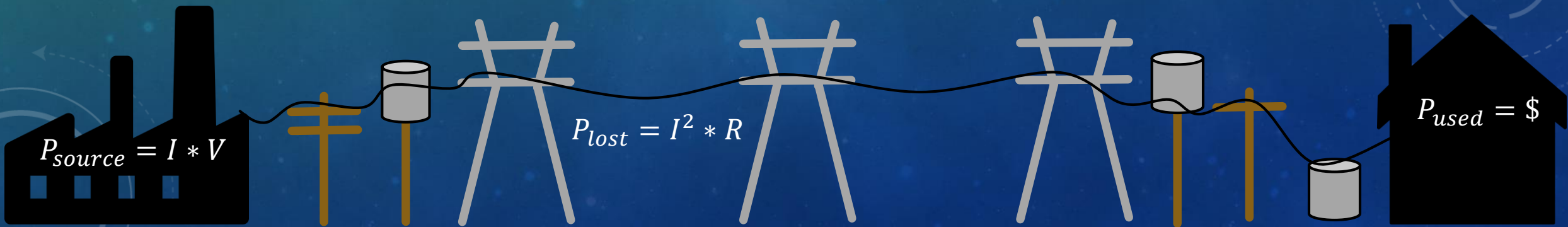
# ALTERNATING CURRENT (AC) CIRCUITS

- In an **AC circuit**, the current moves **back and forth** (usually quickly).
- Rotary electrical generators naturally generate alternating current.
- The **electrons deliver energy** by moving back and forth.
- This is similar to the way a **hand-saw** works.
  - The teeth deliver energy to the wood by their motion.
  - They cut by moving **back and forth**.
- The symbol in a circuit has a **wave-shape** that represents the oscillating current.
- Most **household power** is delivered via **AC** circuits.
  - In the **US**, the oscillation frequency is **60 cycles/s**, with a voltage of **120 V**.
  - In **Europe**, the frequency is **50 cycles/s**, with a voltage of **230 V**.
  - An appliance designed for one system will fail to work in the other.



# NATIONAL POWER DELIVERY

- **Power** is generated at a **central location**.
- Power is **transmitted through power lines** to your house.
- The power lines have a **fixed resistance**, and will **dissipate energy** along the way as heat.
- You only pay for power used at your house, not power lost along the way.
- How does the utility company **minimize loss**?
- They **minimize current ( $I$ )** by **raising the voltage ( $V$ )**
- So, they use **high voltage power lines** for long distances.
- We don't want high voltages coming into the house.
- So, they use **transformers**, which **raise voltage & lower current** on one end. Then they **lower voltage & raise current** on the other end.
- **Transformers** only work in an **AC** system.



# CONCLUSION

- **Batteries** work by having **separated charges** within, and allowing them to re-unite slowly when connected in a circuit.
- Batteries can be connected in parallel or series.
  - In **parallel**, they deliver their **rated voltage**, but last **twice as long** as one battery.
  - In **series**, they deliver **double their rated voltage**, and have a **normal battery lifetime**.
- Current flow through a circuit is either **DC** or **AC**.
  - In **direct current** (DC), the current flows in only **one direction**.
  - In **alternating current** (AC), the current cycles **forward and backward**.
- **Power** delivery is usually accomplished with **AC circuits**.
  - **Generators and motors** work most simply in AC.
  - **Resistive power losses** are **lowered** by using **high voltage, low current**.
  - **Transformers** to **raise** or **lower** the **voltage** only work in AC systems.