

How Electricity Works:

Circuits and Energy



- Training scope and learning objectives for this course



- Why electricity awareness matters for non-electricians



- Roadmap: from basic concepts to safety and troubleshooting



- Ground rules: awareness-level training, not a qualification for electrical work



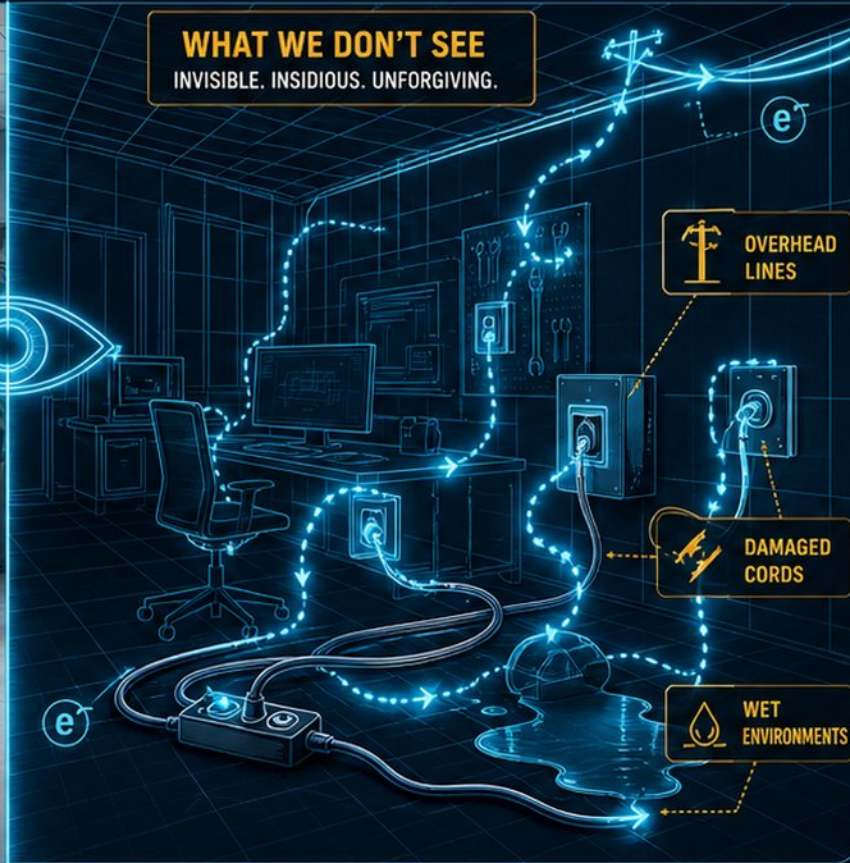
The Hidden Danger: Why Electricity Deserves Respect

WHAT WE SEE



WHAT WE DON'T SEE

INVISIBLE. INSIDIOUS. UNFORGIVING.



SAFE ENVIRONMENT
RIGHT PRACTICES
RIGHT MINDSET



KEY FACTS



- ~150 workplace electrical fatalities per year; 70% in non-electrical jobs



- ~24,000 residential electrical fires annually, ~295 deaths, \$1.2B+ in damage



- Electricity gives no warning: no smell, no sound—until it's too late



- Common scenarios: overhead lines, damaged cords, wet environments

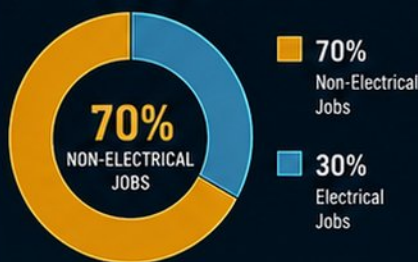


- The goal: recognize hazards, respect boundaries, and stay safe

WORKPLACE FATALITIES (EST.)



FATALITIES BY JOB TYPE



RESIDENTIAL ELECTRICAL FIRES (ANNUAL)



Data reflects annual averages in the U.S.

ELECTRICITY: SILENT BUT DEADLY



No smell. No sound. No warning.
Until it's too late.



RECOGNIZE HAZARDS



RESPECT BOUNDARIES

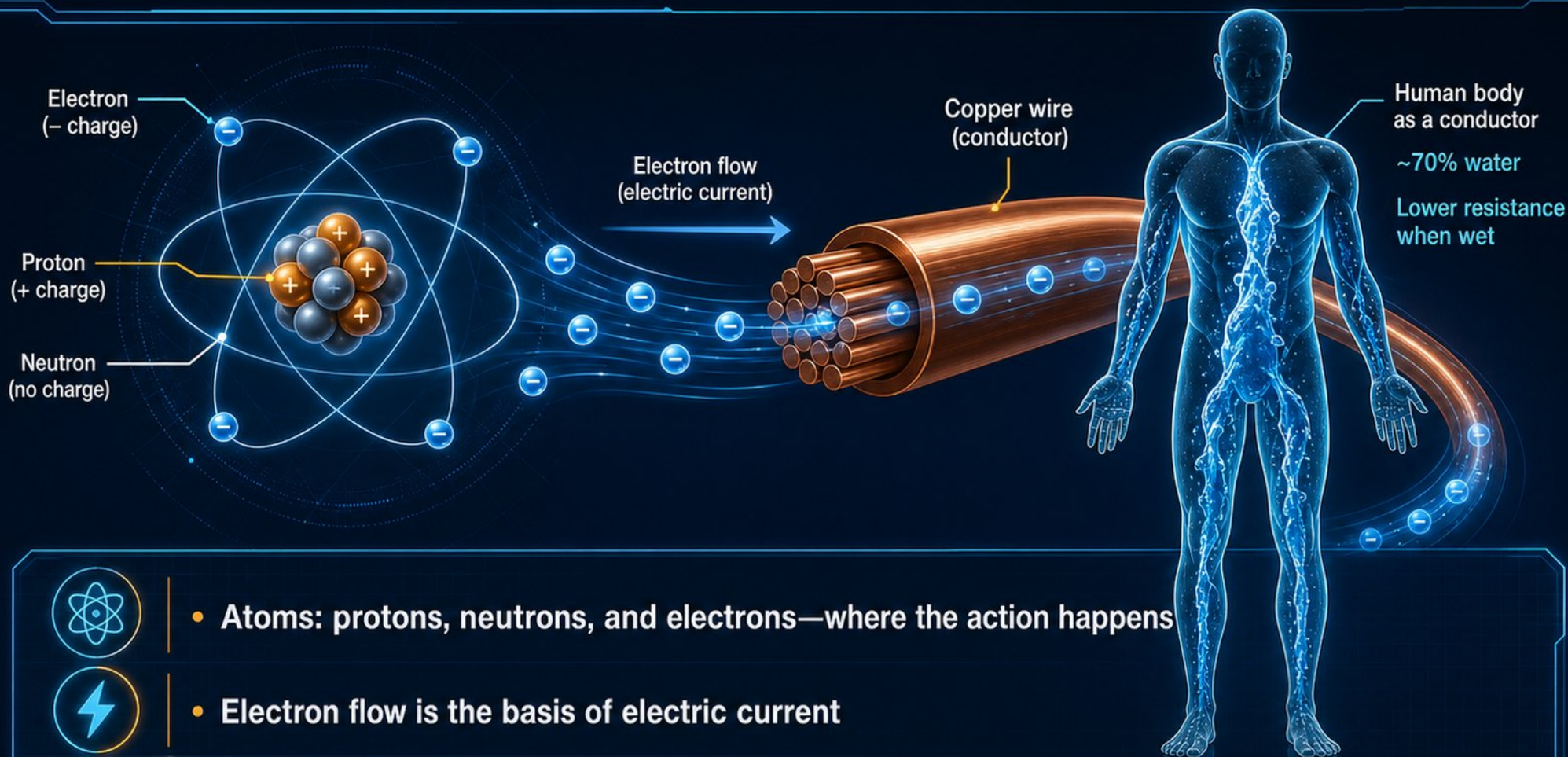


FOLLOW PROCESSES



PROTECT YOURSELF AND OTHERS

What Electricity Really Is: Atoms, Electrons, and Charge



- **Atoms:** protons, neutrons, and electrons—where the action happens



- **Electron flow** is the basis of electric current



- **Conductors, insulators, and semiconductors** control the flow

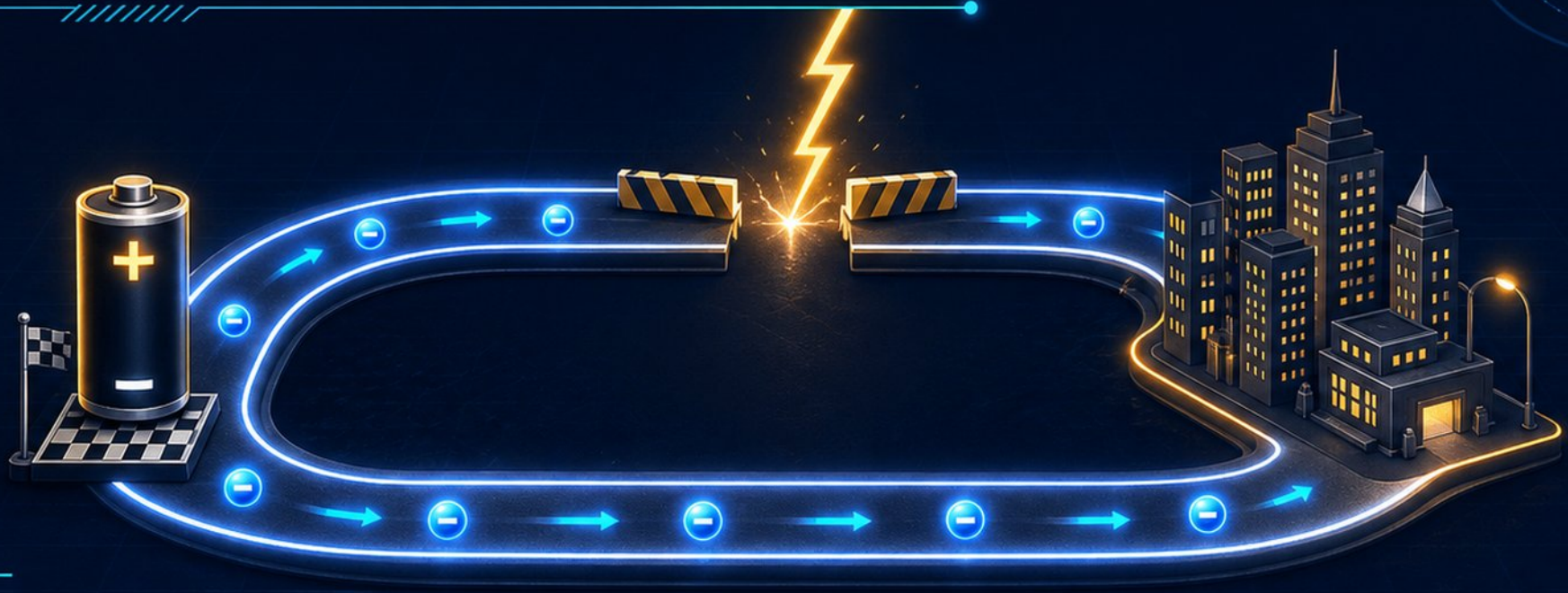


- **The human body is a conductor:** 70% water, lower resistance when wet



- **Voltage** is electrical pressure; **current** is flow rate; **resistance** is opposition

The Closed Loop: How Circuits Work



- Three essential parts: source, load, and conductive path
- Open circuit stops current; closed loop enables flow
- Interrupted circuit: electricity seeks the closest path to ground
- Short circuit bypasses the load, creating dangerously high current
- Real-world causes: damaged insulation, loose connections, moisture, pests, overloads

Voltage, Current, and Resistance: The Water Analogy

- **Voltage (V)** is electrical pressure—the push that moves electrons
- **Current (I)** is the flow rate—the volume of charge moving per second
- **Resistance (R)** opposes flow, like a pipe constriction
- Low resistance + high voltage = dangerously high current flow
- Wet skin dramatically lowers resistance—your body becomes a conductor

WATER PIPE SYSTEM

PRESSURE (Voltage)

The push that moves water



FLOW RATE (Current)

Volume of water flowing per second



RESISTANCE (Resistance)

Opposes flow, like a pipe constriction



HIGH PRESSURE + LOW RESISTANCE = HIGH FLOW

Large flow when pressure is high and restriction is low



ELECTRICAL EQUIVALENT

VOLTAGE (Voltage)

Electrical pressure from a source



CURRENT (Current)

Charge (electrons) moving per second



RESISTOR (Resistance)

Opposes current flow



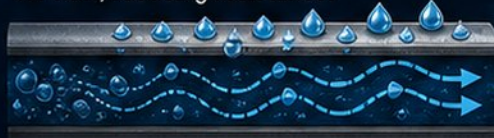
HIGH VOLTAGE + LOW RESISTANCE = HIGH CURRENT

Very high current when voltage is high and resistance is low



WET SURFACE = LOWER RESISTANCE

Moisture provides more paths for flow, reducing resistance.



WET SKIN = LOWER RESISTANCE

Moisture on skin lowers the body's resistance—making it easier for current to pass through.



Ohm's Law: The Single Most Important Rule in Electricity

- $V = I \times R$: Voltage equals current times resistance
- Higher resistance means lower current at fixed voltage
- Low resistance paths (like a wet body) allow dangerously high current



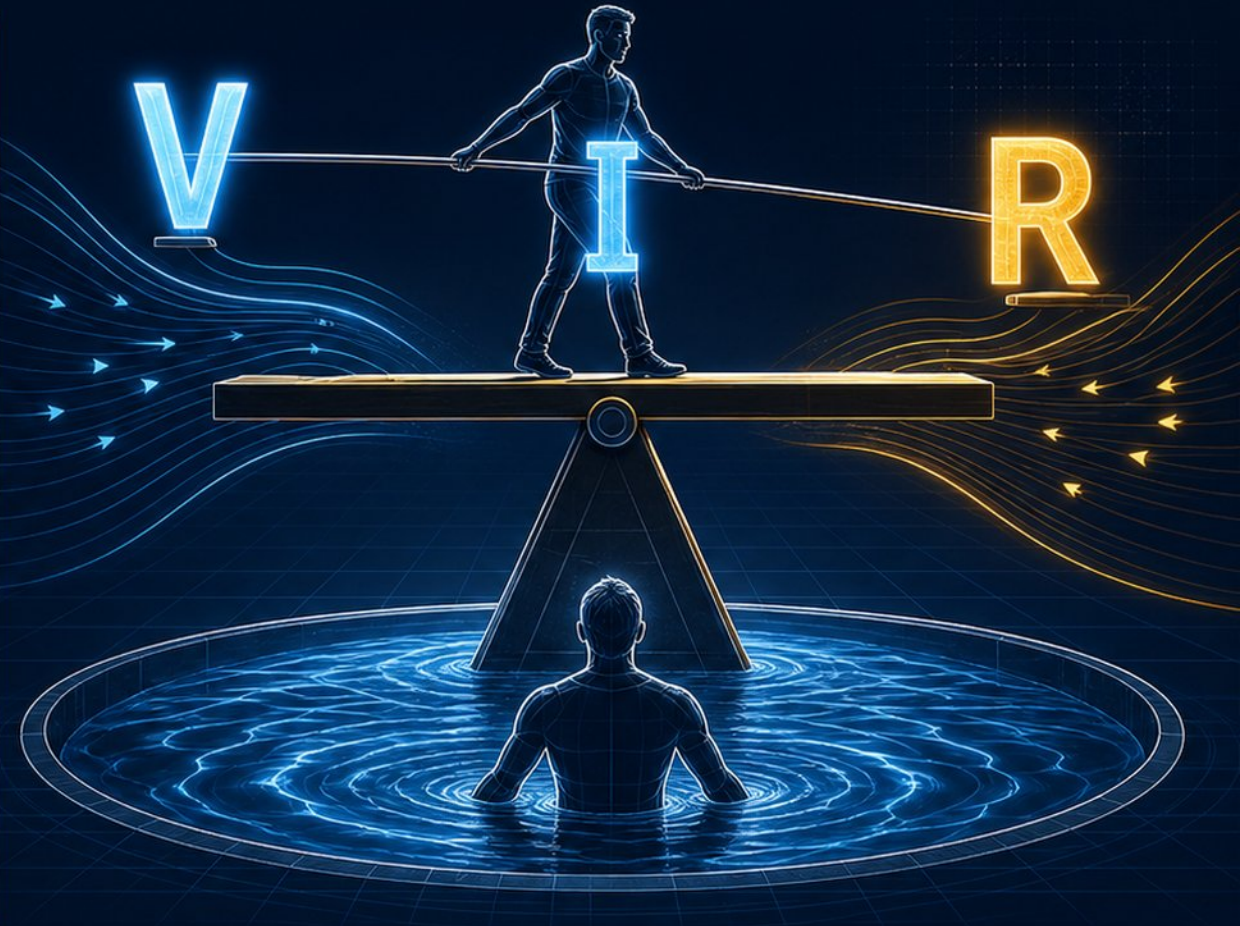
Lamp example:

$$120V \div 240\Omega = 0.5A$$



Short circuit:

$$120V \div 0.01\Omega = 12,000A$$



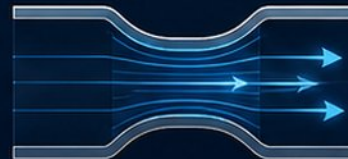
**Water
Analogy
System**



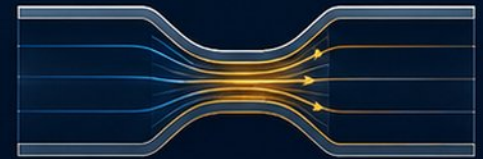
pressure (V)



flow (I)



constriction (R)



Power and Energy:

What You're Actually Paying For



- Power (watts) = rate of use; energy (kWh) = total consumed over time



- $P = V \times I$: appliances draw current and consume power



- Read appliance labels to find wattage and estimate consumption



- U.S. avg. residential rate: ~18.8¢/kWh; typical bill ~\$164/month



- Higher-wattage devices cost more to run; energy efficiency saves money



Series and Parallel Circuits: Two Ways to Connect



- Series circuits: one path, same current everywhere, voltage divides across loads



- Parallel circuits: multiple paths, same voltage across branches, current divides



- Building wiring uses parallel: each device gets full voltage, one failure won't kill the circuit



- Series risk: one broken bulb darkens the whole string; parallel prevents this



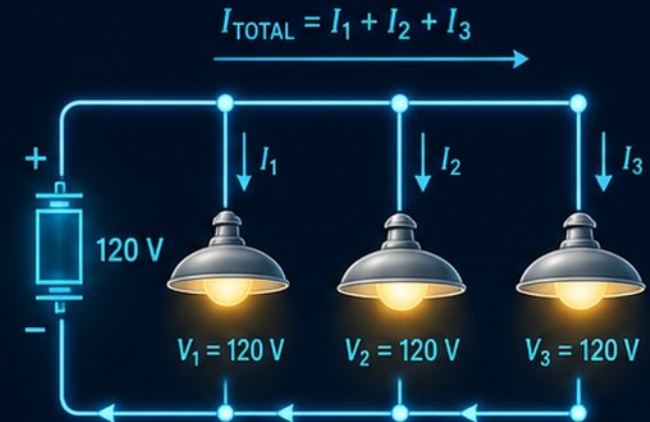
- Visual comparison: current and voltage behave differently in each configuration

SERIES CIRCUIT Single-Path Fairy Light String



Open circuit → No current flows → All bulbs go dark

PARALLEL CIRCUIT Modern Ceiling Light Wiring



Other branches keep working → Circuit continues



CLOSED LOOP & PATH OF LEAST RESISTANCE

Electric current flows only in a **closed loop**, from the positive terminal to the negative terminal. It takes the path of **least resistance** available.



Current naturally chooses the easiest (lowest resistance) route.

→ Arrows = Direction of Current Flow (I)

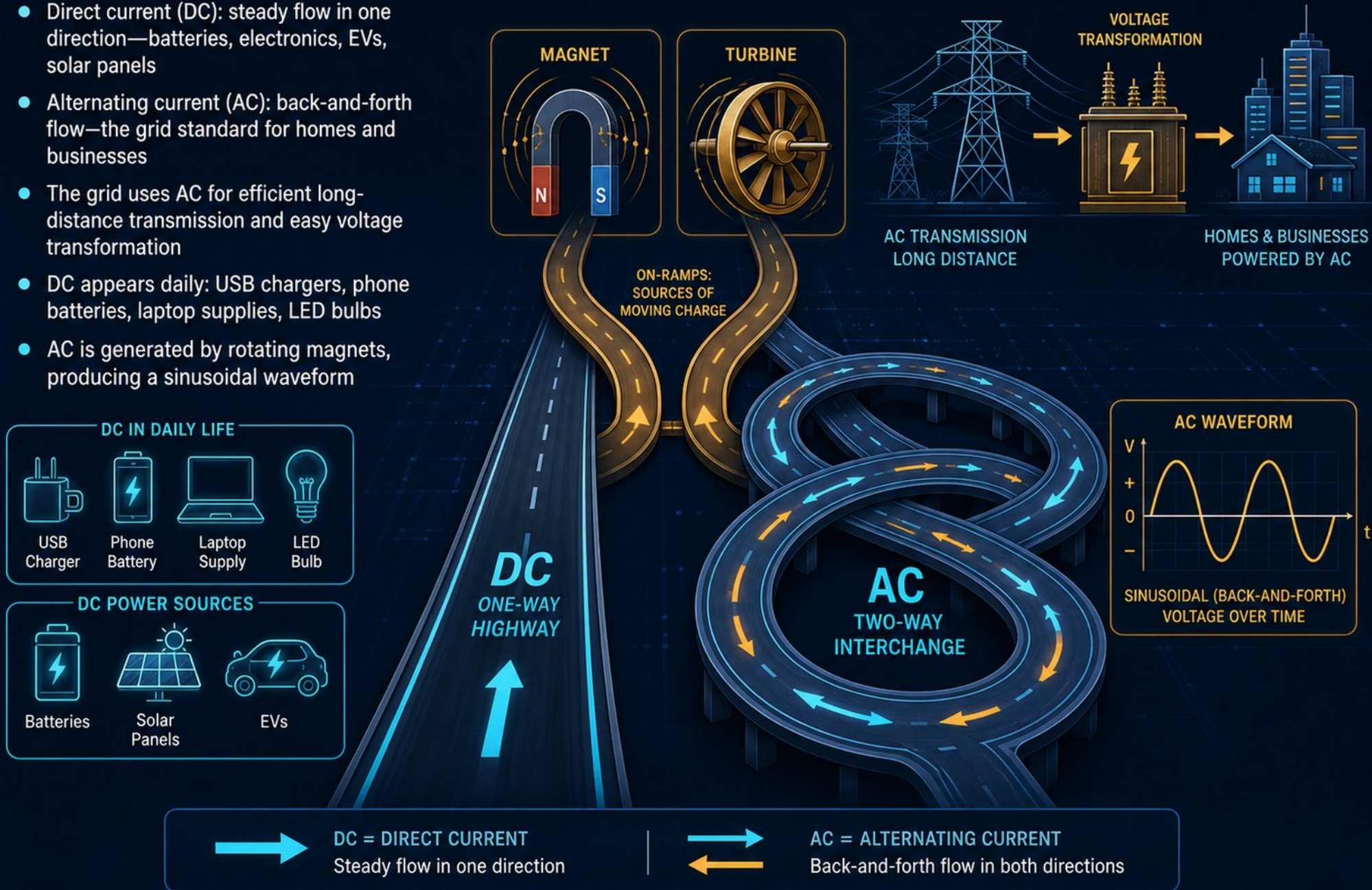
V = Voltage (Volts)

I = Current (Amperes)

• = Connection (Node)

AC and DC: Two Ways to Move Charge

- Direct current (DC): steady flow in one direction—batteries, electronics, EVs, solar panels
- Alternating current (AC): back-and-forth flow—the grid standard for homes and businesses
- The grid uses AC for efficient long-distance transmission and easy voltage transformation
- DC appears daily: USB chargers, phone batteries, laptop supplies, LED bulbs
- AC is generated by rotating magnets, producing a sinusoidal waveform



Protecting People: Shock, Burns, and the Body's Vulnerability



- Three primary hazards: shock, arc flash, and arc blast



- Current causes muscle contractions; above let-go threshold, you can't release



- Dry skin has high resistance; wet skin dramatically lowers it



- Hand-to-hand current path across the chest is especially lethal



- Even low voltages can kill: respect electricity regardless of source

ELECTRONS →



ENTRY POINT
Current enters at the left hand

HAND-TO-HAND CURRENT PATH
Across the chest through vital organs (heart, lungs)

SKIN RESISTANCE MATTERS

DRY SKIN
HIGH RESISTANCE

Current faces more opposition.
Less current flows.

WET SKIN
LOW RESISTANCE

Current flows more easily.
Much lower resistance.

EXIT POINT
Current exits at the right hand

THE HUMAN BODY
is a conductor.
Electricity will take the available path.



RESPECT ELECTRICITY. PROTECT PEOPLE. PREVENT TRAGEDY.

Protecting Circuits: Fuses, Breakers, GFCIs, and Grounding



- Fuses and breakers: overcurrent protection, prevent wire overheating and fires



- GFCIs: detect as little as 5 mA leakage, shut off in milliseconds



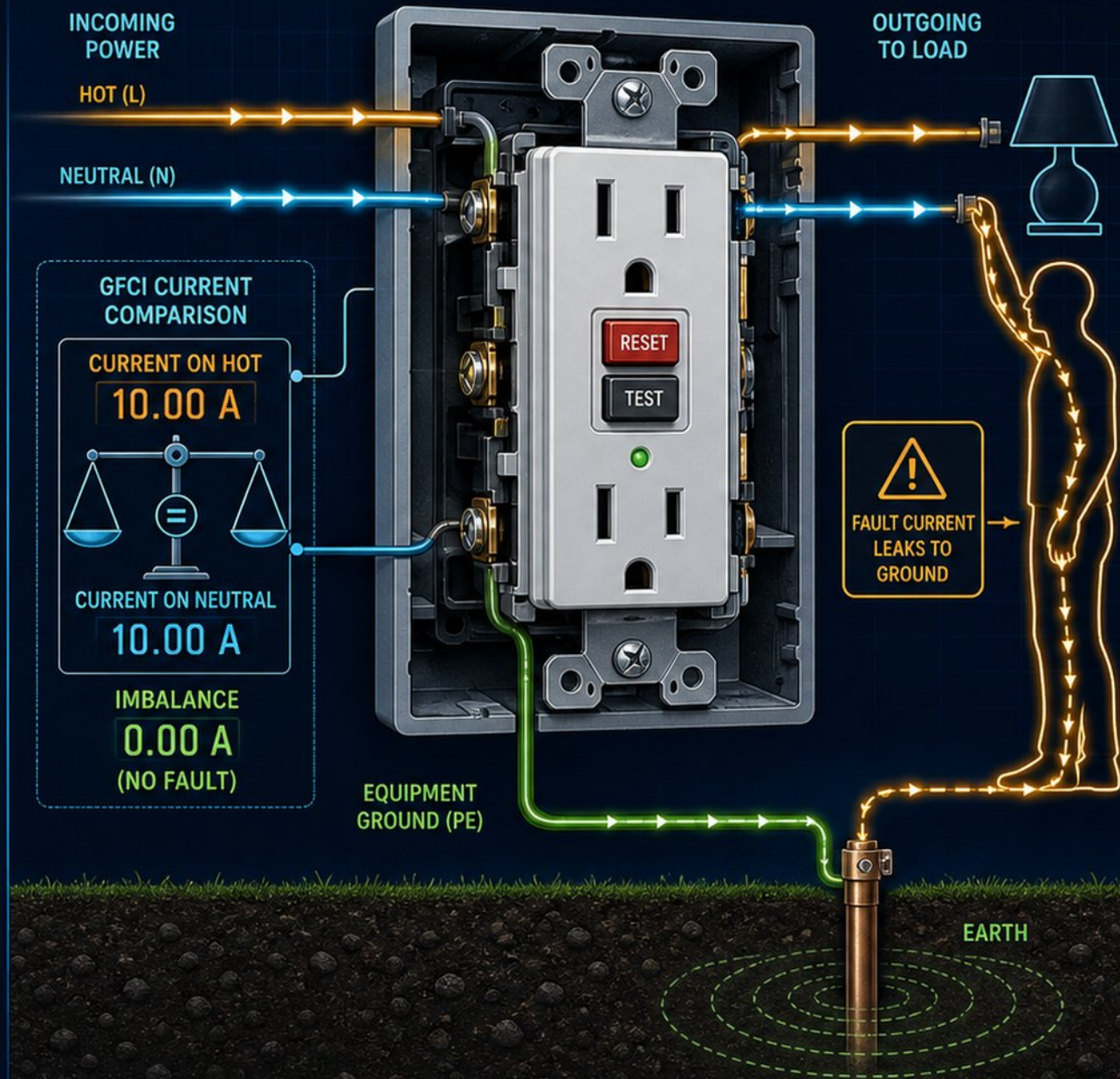
- GFCI logic: compares current on hot and neutral; imbalance means a fault—possibly through a person



- Grounding: provides a safe, low-resistance path to earth for fault current



- RCDs: international equivalent of GFCIs, ≤ 30 mA trip threshold



Recognizing Hazards: What to Look for Every Day



- **Exposed live parts:**
missing covers, open panels,
damaged outlets



- **Damaged cords and plugs:**
frayed insulation, bent prongs,
cracked casings



- **Overloaded circuits:**
too many devices on one outlet,
daisy-chained power strips

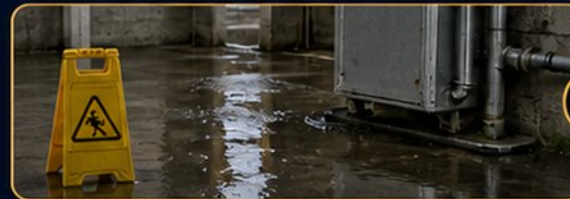


- **Overhead power lines:**
the #1 killer in non-electrical
occupations (57% of fatalities)

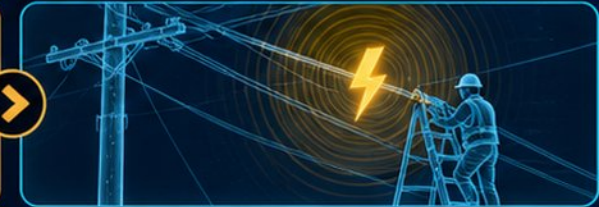
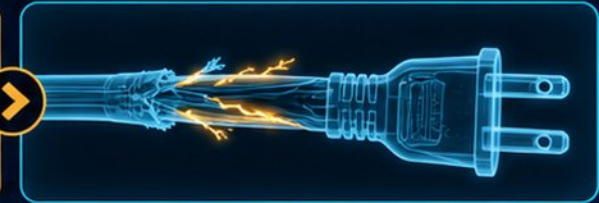


- **Environmental risks:**
wet conditions, cramped
spaces with earthed metal,
outdoor exposure

VISIBLE (WHAT YOU SEE)



HIDDEN DANGER (X-RAY VISION)



VISIBLE (WHAT YOU SEE)

Problems you can spot



HIDDEN DANGER (X-RAY VISION)

The electrical hazards you can't always see

Safe Work Practices for Non-Electricians



- “NEVER touch a powered circuit—always verify power is off yourself”



- “Inspect tools and cords before each use; tag and remove defects”



- “Use GFCIs in kitchens, bathrooms, outdoors, and all damp areas”



- “Never daisy-chain power strips; plug directly into wall outlets”



- “Stop and report unsafe conditions—escalate to a qualified person”



SAFETY CHECKLIST

- ✓ Cord intact (no cuts or frays)
- ✓ Plug in good condition
- ✓ Tool housing undamaged
- ✗ No exposed wires
- ✗ Do not use if damaged—tag out



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Emergency Response:

What to Do When Something Goes Wrong



DO NOT touch a person receiving a shock—you become a second victim



Disconnect power at the source if possible; call 911 immediately



Electrical shocks always need emergency medical attention—hidden internal injuries are common



Check for secondary injuries: falls, fractures, bleeding; apply pressure, elevate wounds



Do not use water on electrical fires; use a Class C fire extinguisher



DO NOT TOUCH



THE HUMAN BODY AS A CONDUCTOR



Electricity seeks the easiest path to ground

Can disrupt heart rhythm and vital organs

Can cause severe internal damage or death

IS THE AREA SAFE FOR YOU TO ACT?

NO



Do **NOT** enter.
Call 911 from a safe location.

YES



DISCONNECT POWER AT THE SOURCE
Turn off the circuit breaker or remove the plug.



Switch **OFF** to cut power



CALL 911

Provide location, condition of victim, and what happened.

911

Building a Simple Circuit: Hands-On Demonstration

-  “Build a real circuit: battery, wires, switch, lamp—same elements as any building wiring”
-  “Measure voltage and current with a multimeter—the essential troubleshooting tool”
-  “Troubleshoot methodically: check source, then connections, then load”
-  “Reinforces core concepts: voltage, current, resistance, power, closed loop”
-  “Builds the mental model to recognize real hazards—not a qualification to perform electrical work”



The diagram is split into two panels. The left panel, titled 'SAFE: CLOSED CIRCUIT', shows a battery with a '+' sign and a bracket labeled 'VOLTAGE (PUSH)'. A wire connects the positive terminal to a glowing light bulb. Another wire connects the light bulb to a resistor, labeled 'RESISTANCE (OPPOSES)'. The wire then returns to the negative terminal of the battery. Arrows indicate the direction of 'CURRENT (FLOW)'. The right panel, titled 'HAZARDOUS: YOU ARE THE PATH', shows a similar battery setup. However, the wire from the positive terminal goes to a person's hand, and the wire from the person's foot goes back to the negative terminal. A lightning bolt symbol is shown inside the person's outline. To the right of the person is a warning triangle with a lightning bolt and the text 'DANGER: HIGH RISK OF SERIOUS INJURY OR DEATH'. A central 'VS.' circle separates the two panels.

SAFE: CLOSED CIRCUIT
Path is complete—current flows safely to power the load.

HAZARDOUS: YOU ARE THE PATH
Your body completes the circuit—electricity flows through you.

VS.

DANGER:
HIGH RISK OF
SERIOUS INJURY
OR DEATH



- Most electrical deaths involve well-understood hazards the victim was never taught to recognize

Resources for Continued Learning



- Free online textbook: All About Circuits—DC, AC, digital, and projects



- Khan Academy's Intro to Electrical Engineering—strong beginner path



- Interactive simulation tools: CircuitJS and Tinkercad Circuits



- Structured beginner courses: Ohmify, Start Electronics Now, and Make-It Guides



- Workplace safety resources: OSHA.gov, NFPA 70E, and ESFI materials



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