Robotics From Scratch
Lesson 4: Electricity Basics - Summary Handout

Key Concepts

Fundamental Definitions

- **Voltage (V):** Electrical "pressure" in Volts
- **Current (I):** Flow of charge in Amperes
- **Resistance (R):** Opposition to flow in Ohms (Ω)
- **Power (P):** Energy rate in Watts

Essential Formulas

$$V = I \cdot R \quad \text{(Ohm's Law)}$$
$$P = I \cdot V \quad \text{(Watt's Law)}$$
$$P = I^2 \cdot R = \frac{V^2}{R}$$

SI Prefixes

Name	Symbol	Value
milli	m	10^{-3}
micro	μ	10^{-6}
kilo	k	10^3
mega	M	10^6

AC vs DC

DC: Current flows one direction (batteries, electronics)

AC: Current reverses direction (wall outlets, 60Hz)

Circuit Basics

- Circuit = closed loop
- Ground = 0V reference
- Polarity matters!

Practice Problems

Problem 1: Basic Ohm's Law

9V battery, $470\,\Omega$ resistor. Find:

a) Current

b) Power dissipated

Problem 2: Find Resistance

Motor draws 1.5A from 12V supply. Find motor resistance.

Problem 3: Series Circuit

Resistors: $100\,\Omega$, $220\,\Omega$, $330\,\Omega$ in series, 12V battery. Find:

a) Total resistance

b) Current

c) Voltage drop across each

Hint: $R_{total} = R_1 + R_2 + R_3$

Problem 4: Power & Battery Life

Motor: 2.5A from 6V battery (2000mAh capacity)

a) Power consumed?

b) Run time?

Python Programming Exercises

Exercise 5: Ohm's Law Calculator

Create a program that calculates V, I, or R given the other two values. Include unit conversions (mA $\leftrightarrow$ A, k$\Omega \leftrightarrow \Omega$).

Starter Code:

```python
def calculate_voltage(current, resistance):
    return current * resistance

def calculate_current(voltage, resistance):
    return voltage / resistance

def calculate_resistance(voltage, current):
    return voltage / current

# TODO: Add user input, menu, unit conversions, error handling
print("=== Ohm's Law Calculator ===")
```

Exercise 6: Series Resistor Calculator

Program that accepts resistor list, calculates total resistance, current, voltage drops, and displays formatted table.

Example Output:

```
Resistors:  [100, 220, 330] ohms | Supply:  12V
Total R: 650Ω | Current:  18.5 mA
```

Resistor	Voltage	Power
100 Ω	1.85 V	0.034 W
220 Ω	4.07 V	0.075 W
330 Ω	6.11 V	0.113 W

Further Study Topics

Series vs Parallel Circuits

Series Circuits:

- Components share same current
- Voltages add: $V_{total} = V_1 + V_2 + ...$
- Resistances add: $R_{total} = R_1 + R_2 + ...$
- Used in: voltage dividers, Christmas lights
- Drawback: One break stops all
- **Batteries in series:** Voltages add (e.g., two 1.5V AA batteries = 3V)

Parallel Circuits:

- Components share same voltage
- Currents add: $I_{total} = I_1 + I_2 + ...$
- Reciprocal: $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + ...$
- Used in: home wiring, power distribution
- Advantage: Independent operation
- **Batteries in parallel:** Voltage stays same, capacity (mAh) adds for longer runtime

Internal Resistance

Real-world power sources aren't perfect. Batteries and power supplies have internal resistance ($r_{internal}$) that:

- Causes voltage to drop when supplying current: $V_{actual} = V_{rated} - I \cdot r_{internal}$
- Limits maximum deliverable current
- Increases as batteries discharge or age
- Critical consideration for high-current robotics applications (motors, servos)
- Why you might see voltage "sag" when motors start

Recommended Resources

- **All About Circuits** - Comprehensive free textbook: `www.allaboutcircuits.com`
- **Khan Academy** - Electrical Engineering fundamentals with video tutorials
- **Falstad Circuit Simulator** - Interactive browser-based circuit simulator `www.falstad.com/circuit/`

Next Class Preview: Components, Schematics, & Breadboards

- **Components:** Resistors, capacitors, diodes, LEDs, switches, transistors
- **Schematics:** Reading circuit diagrams and symbols
- **Breadboard Layouts:** Translating schematics to physical builds
- **Hands-on:** Circuit assembly and troubleshooting
- **Datasheets:** Reading component specifications

Practice makes perfect! Build circuits and experiment with different values.