Physics Reference

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Contents

Chapter 1

Introduction

This chapter will offer reference and information that applies to the entire book.

1.1 Standard Units

In physics it's often important to have precisely defined units for the purposes of making very accurate measurements or simply having a coherent unit system. It's possible to derive all necessary units from five measurements of **length, mass, time, current, and temperature**. The standard SI units for these properties are listed bellow:

Type	Unit	Definition
Length	Meter(m)	Length of distance light in a vacuum travels in $\frac{1}{299792458}$ seconds
Mass	Kilogram(kg)	Defined by fixing the Planks constant $h = 6.62607015 \times 10^{-34} kg\ m^2 s^{-1}$
Time	Second(s)	Defined by fixing the ground-state hyperfine transition frequency of the caesium-133 atom, to be $9192631770 s^{-1}$
Current	Ampere(A)	Defined by fixing the charge of an electron as $1.602176634 \times 10^{-19} A \cdot s$
Temperature	Kelvin(K)	Defined by fixing the value of the Boltzmann constant k to $1.380649 \times 10^{-23} kg \cdot m^2 s^{-2} K^{-1}$

Common prefixes are listed bellow:

Prefix	Symbol	Definition
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Chapter 2

Electricity and Magnetism

2.1 Electronics

Definition 2.1.1. Electric Field force per unit charge or N/C

Definition 2.1.2. Voltage or *Potential* is the change in energy per unit charge brought on by traveling through an electric field or J/C or simply V

Remark. The units N/C is equivalent to V/m

Definition 2.1.3. Power can be derived from units of current and voltage for the following formula where P is power(W), V is voltage(V), and I is current(A).

$$P = VI \tag{2.1.1}$$

Law 2.1.1. Ohms Law models the voltage drop across a purely resistive load with the following formula where V is voltage(V), I is current(A), and R is resistence(Ω).

$$V = IR \tag{2.1.2}$$

Definition 2.1.4. A **Resistor** a device that will produce a voltage drop according to ohms law with a resistance as V/A

Definition 2.1.5. Resistivity($\Omega\,$m) is used to calculate how much resistance we expect from a material use the following formula where R is resistence(Ω), ρ is **Resistivity**($\Omega\,$m), l is length(m), and A is cross sectional area(m^2).

$$R = \rho\frac{l}{A} \tag{2.1.3}$$

Law 2.1.2. Kirchoff's Voltage Law states precisely that the algebraic sum of all voltages around a closed path is zero.

$$\sum V_n = 0 \tag{2.1.4}$$

Law 2.1.3. Kirchoff's Current Law states precisely that the algebraic sum of all currents entering a node is zero.

$$\sum I_n = 0 \tag{2.1.5}$$

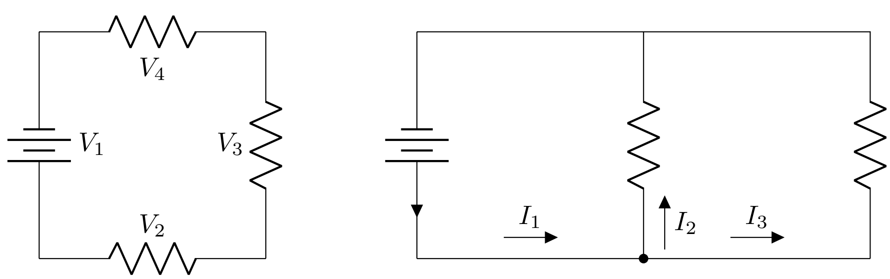


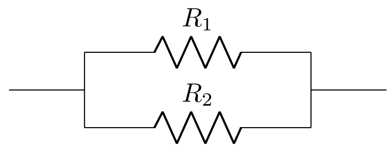
Figure 2.1: Two circuits to demonstrate Krichhoff's Laws

Definition 2.1.6. Effective Voltage or **Root Mean Square Voltage** is the voltage $V_p/\sqrt{2}$ where V_p is the peak sinusoidal voltage. This represents the DC voltage that would produce the same power draw as the AC voltage.

Law 2.1.4. Resistors in Series will simply be the sum of the individual resistance because we are adding the length of the resistors together.

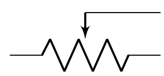
$$R_T = \sum R_i \tag{2.1.6}$$

Law 2.1.5. Resistors in Parallel will decrease the overall resistance as indicated by the definition of resistivity 2.1.5.

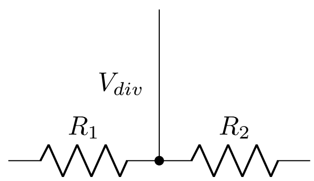


$$\frac{1}{R_T} = \sum \frac{1}{R_i} \tag{2.1.7}$$

Definition 2.1.7. Voltage Divider or **Potentiometer** is a arangement of two resistors with a connection between them. A potentiometer refers to a voltage divider where the resistance ratio between the two resistors can be adjusted.



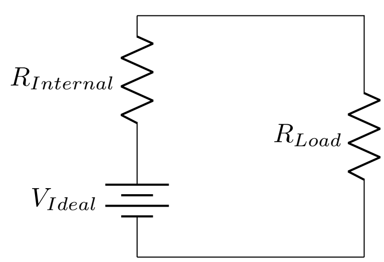
To calculate the voltage we expect at the divider we need to know the voltage across the whole potentiometer V and the ratio between the two resistors $\frac{R_2}{R_1}$.



$$V_{div} = V\frac{R_2}{R_1 + R_2} \tag{2.1.8}$$

Definition 2.1.8. Ideal Battery - a battery that always produces the same potential difference.

Definition 2.1.9. Real Battery - a battery with some internal resistance that reduces the potential difference across the terminals depending on the amount of current.

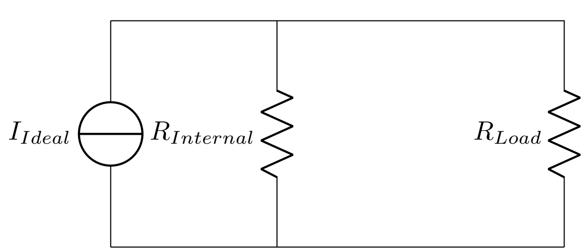


$$V_{Real} = V_{Ideal} - IR_{Internal}$$

$$V_{Real} = V_{Ideal}\frac{R_{Load}}{R_{Internal} + R_{Load}} \tag{2.1.9}$$

Definition 2.1.10. Ideal Current Source - a device that always provides that same current to a load.

Definition 2.1.11. Real Current Source - a current source with an internal resistance connected in parallel that reduces the current produced when the load resistance is high.



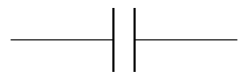
$$I_{Real} = I_{Ideal} - \frac{V}{R_{Internal}}$$

$$I_{Real} = I_{Ideal}\frac{R_{Internal}}{R_{Internal} + R_{Load}} \tag{2.1.10}$$

Definition 2.1.12. A **Capacitor** is a device that accumulates a charge q when a voltage v is applied with a proportionality constant C with units $\mathrm{F(farad)} = \mathrm{C\,V^{-1}} = \mathrm{C^2\,J^{-1}}$

$$q = Cv \tag{2.1.11}$$

$$i = C\frac{dv}{dt} \tag{2.1.12}$$



Remark. The energy stored in a capacitor can derived by integrating power over time:

$$\omega_C = \frac{1}{2}Cv^2 \tag{2.1.13}$$

Definition 2.1.13. An **Inductor** is a device which accumulates a magnetic flux $\phi = BA$ when a current is applied with a proportionality constant L with units $\mathrm{H(henry)} = \mathrm{J\,A^{-2}}$

$$\phi = Li \tag{2.1.14}$$

$$v = L\frac{di}{dt} \tag{2.1.15}$$

Remark. The energy stored in an inductor can derived by integrating power over time:

$$\omega_L = \frac{1}{2}Li^2 \tag{2.1.16}$$