

ELECTRIC CIRCUITS: USING RESISTORS

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Supplementary Material for
PHY1308 (General Physics -
Electricity and Magnetism)

ANNOUNCEMENTS

- Homework 6:
 - Available later today
- Exam 2:
 - In-class, Thursday March 10
 - Covers Ch. 23-24 (Homework 3-5)
- Picking up old material
 - Henceforth, available in FS102 (Physics Main Office)
 - Ask for material at front desk

GEORG SIMON OHM



1789-1854

German physicist who began his studies using the newly developed "electrochemical cell" (battery) invented by Italian Count Alessandro Volta.

Published in 1827 his discovery of a relationship between current and voltage.

UNITS AND CONVERSIONS

$V = IR$ The unit of resistance (R) is the “Ohm”:
 $\Omega = \text{Ohm}$

$$1 \Omega = 1 V / A = 1 V / (C / s) = 1 (V / C) s$$

$V = I \left(\frac{\rho L}{A} \right)$ The unit of resistivity (ρ) is the $\Omega \cdot m$,
“Ohm-meter”:

$$1 \Omega \cdot m = 1 (V / A) \cdot m = 1 (V / C) (m \cdot s)$$

EXAMPLE: COPPER WIRE

- How much electric field is needed to drive 15A of current through a 1.8mm diameter copper wire?
 - copper resistivity: $1.68 \times 10^{-8} \Omega\text{m}$
 - Big voltage or little voltage?

EXAMPLE: COPPER WIRE

- How much electric field is needed to drive 15A of current through a 1.8mm diameter copper wire?
 - copper resistivity: $1.68 \times 10^{-8} \Omega\text{m}$

$$E = J \rho = \frac{I \rho}{A} = 99 \text{ mV/m}$$

- A small electric field is needed to move a large current through a good conductor

EXAMPLE: COPPER WIRE

- Flip the problem around: how much current can a 110V potential drive through 300m of such wire? $R = 1.98\Omega$
 - Answer: about 218A
 - Typical 1500 square-foot house has about 300m of copper wiring.
 - Yikes!
 - Might it be bad to remove the appliance from the end of its electrical cable and then short the cable?

EXAMPLE: COPPER WIRE

- How much power is being dissipated in the copper wire when it's shorted?
 - Answer:

$$P = IV = (218 \text{ A})(110 \text{ V}) = 2.4 \times 10^4 \text{ J/s} = 24 \text{ Thousand Watts}$$

- What does this equal? House fire!
- NEVER SHORT CIRCUIT YOUR HOUSE WIRING!!!

EXAMPLE: HUMAN

- You accidentally stick one finger from each hand in the slots of an electrical outlet (110V). How much current goes through your body under perfectly dry conditions?

- Answer:

$$I = V / R = (110 \text{ V}) / (10^5 \Omega) = 1.1 \text{ mA}$$

- Will you feel this? Is it enough to kill?

USEFUL NUMBERS

- Current and human biology
 - 0.5-2.0 mA
 - threshold of sensation
 - 10-15 mA
 - involuntary muscle contractions; can't let go
 - 15-100 mA
 - Severe shock; muscle control lost; breathing difficult
 - 100-200mA
 - Fibrillation of heart; death within minutes
 - >200 mA
 - Cardiac arrest; breathing stops; severe burns

DON'T TASE ME, BRO!

- What are the properties of a Taser (stun gun)?
 - Voltages in the range 50-1000 kV
 - Delivered to the body? More like 1500V
 - What current goes through your body?
 - ANSWER:
 - That's about 15mA - in the range to paralyze



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