Welcome to PHYS-158

Introductory Physics for Engineers - II

Section 201 (Mon Wed Fri 9:00 – 10:00)

Dr. Marina Litinskaya

Instructor: Dr. Marina Litinskaya

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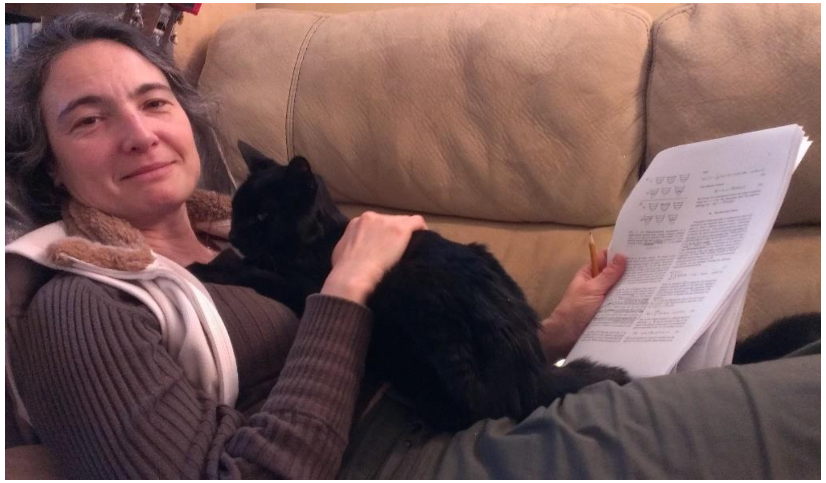


Email: mlit@phas.ubc.ca

Office: Henn 334

Office hours: Hebb 112

- Wed 13:00 – 14:00
- Fri 10:00 – 11:00

Research interests: Optics and spectroscopy of atoms, molecules and nanostructures (theory)

- Same said in a different way: I use light to learn about what's going on inside gases and solids, and to manipulate various processes in atoms and molecules.

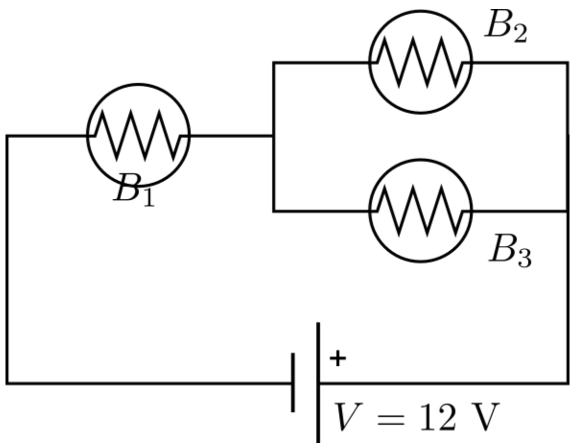
Teaching: PHYS 100, 131, 118, 157, 158, 159, 170, 333

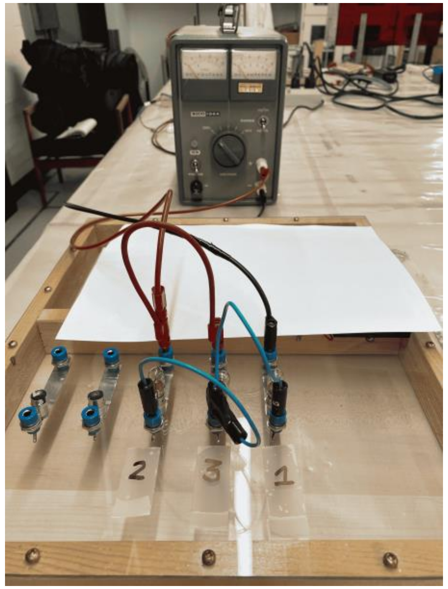
PHYS 158: Electricity and Magnetism: Tentative schedule

Week 1	DC circuits, Kirchhoff’s Laws, Emf and batteries (Ch 25)
Week 2	Capacitors, Time-dependent RC circuit analysis (Ch 24, 26)
Week 3	Inductors, LR, LC circuits (Ch 30)
Week 4	Alternating current circuit analysis. LCR series circuits (Ch 31)
Week 5/6	Electric force and Electric field, Superposition (Ch 21)
	Mid-Term Break Feb 19 – 23, 2024
Week 7	Electric flux & Gauss's law. Electric potential (Ch 22,23)
Week 8	Electric potential (continued), relation to electric field (Ch 23)
Week 9	Magnetic field, Lorentz force, Cyclotron motion (Ch 27)
Week 10	Sources of Magnetic Field, Ampere's law (Ch 28)
Week 11	Electromagnetic Inductions, Faraday's law, Lenz’s law (Ch 29)
Week 12	Electromagnetic waves, Maxwell's equations, Poynting vector (Ch 32)
Week 13	Catchup / review / …

Q: What do you think you know about electric circuits?

A. I have studied them at high school, and feel very confident about them
B. I have studied them at high school, and have some idea about them
C. I have studied them at high school, but let's better assume that I didn't
D. I have never studied them at high school



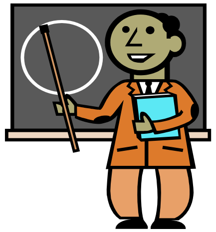


What you will get from this course?

- You will learn some properties of circuits, currents, charges, magnets, EM radiation, and some fundamental laws that orchestrate their lives;
- You will learn how to make quantitative predictions about them using certain mathematical techniques (including integration and vector analysis)
- You will become familiar with important abstract concepts (*field, potential*)
- Scientific (logical) thinking!

Course structure

- Pre-lecture reading:
  - Key elements on which lectures are built
  - Reading quizzes (due Monday 8:59 am starting from Week 2)



- Lectures:
  - ML: Introduce topics
  - We all: sense making / details (iClickers)

- Tutorials:
  - Led by TA
  - Solve advanced problems in groups
  - Mark: active participation & reflection

- Homework:
  - MC or Numerical: on Mastering Physics
  - Long-Answer: on Gradescope
  - Due Sundays 11:59 pm

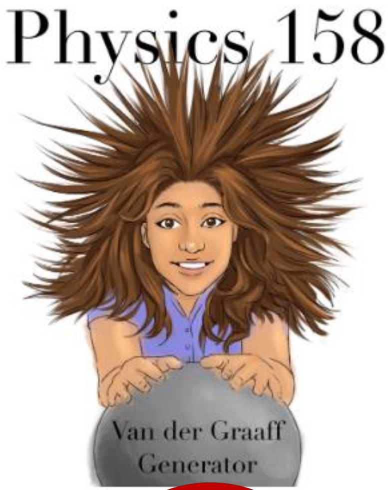
- Midterms 1 and 2, and Final exam

What will you need and where to find it?

- Midterm 1:
  Thu Feb 29, 6:30 pm
- Midterm 2:
  Mon Mar 25, 6:30 pm

- Home
- Announcements
- Modules
- Piazza
- Gradescope
- Assignments
- Quizzes
- Grades
- iClicker Cloud
- Course Evaluation
- Evaluation Reports

Course Content by Week
Week 1: Jan 8 - 12
Week 2: Jan 15 - 19



- **Phys 158 first-week checklist (helps to set everything up)**
- **RA Week 1 (optional)**
- **RA Week 2 (due Jan 15th by 9 am)**

PHYS 158
Syllabus

- **All course documents**

(due dates, policies, ...)

Meet your Teaching Team!	Course Structure	Learning Goals
Course Schedule	Tutorial Workshops Schedule	Grading Rubric
Resources and Practice Exams	Exams	Academic Integrity
Student Health and Wellbeing	Learning Material	Academic Help

Grading Rubric

Pre-reading Quizzes	3%
Tutorial Workshops	5%
Mastering Physics Homework	5%
Written homework	7%
Midterm 1	15%
Midterm 2	20%
Final exam	45%

- Your April exam grade will replace your overall course rubric grade if it is higher (but please don't rely on that!).
- You must obtain a minimum grade of 45% on the final exam and 50% on the average of your written exams (MT1, MT2, April) to receive your rubric grade.

Academic concessions

- If you are sick, have personal issues, are in trouble, etc.: contact our course coordinator, Megan Bingham!
- Please contact Megan before the due date of the assignment you need an accommodation for.
- You need to submit the academic concession form and briefly explain why do you need a concession.

- You are always very welcome to contact your instructor (me) if you are having issues that impact your progress and you think I might be of help.

What to expect?

- This year we are restarting PHYS 158 and make major changes to the course content.
- Such a course is a complex mechanism with many parts that, ideally, should interact with each other smoothly.

- Please help up to make this course better! Some turbulence is unavoidable, but we hope that you will enjoy the flight.

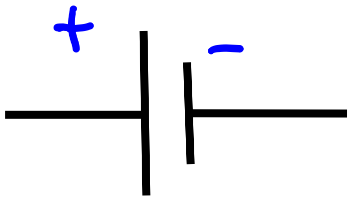
- Fasten your seatbelts, and let’s go!

Time-independent DC circuits with resistors

Text: 26.1-2; 25.3 (first section); 25.4; 25.5

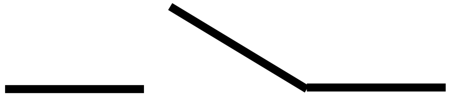
- Ch 26.1 – Resistors in series and in parallel
- Ch 26.2 – Kirchhoff's laws: Junction $(\Sigma I_{in} = \Sigma I_{out})$ & Loop $(\Sigma V_{abcdea} = 0)$
- Ch 25.3 – Ohm's law (V = IR)
- Ch 25.4 – EMF, Internal battery resistance
- Ch 25.5 – Energy and Power $(P = \frac{\Delta E}{\Delta t} = IV)$, Real batteries

Basic DC circuit components (DC = “direct current”)



DC power supply
or Battery: V, or ε

(supplies electric power)

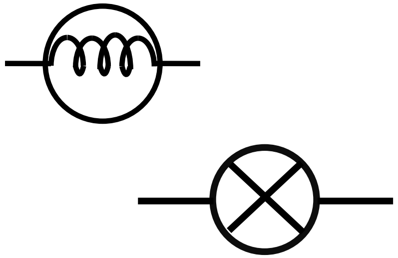


Switch: S

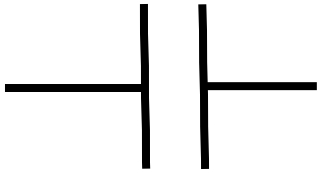
(changes geometry of circuit)

Resistor: R

(consumes
electric power)

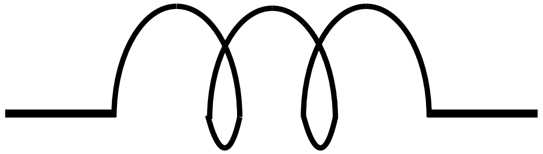


Light Bulb
is a resistor



Capacitor: C

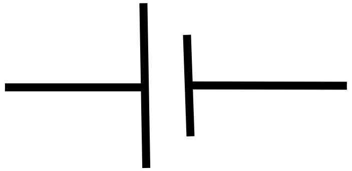
(stores / releases
electric energy)



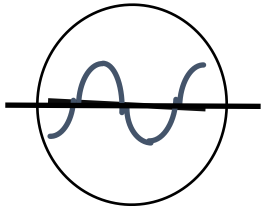
Inductor: L

(stabilizer)

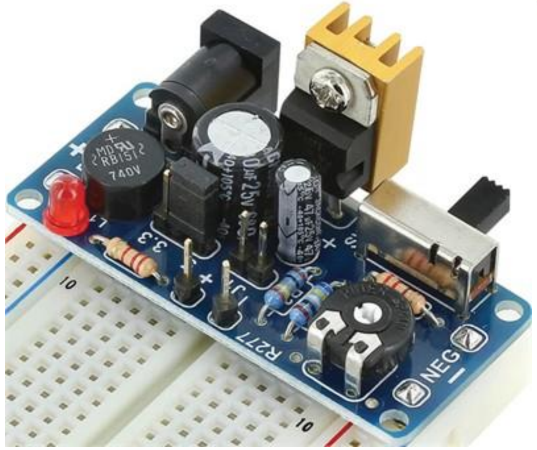
Power Supplies

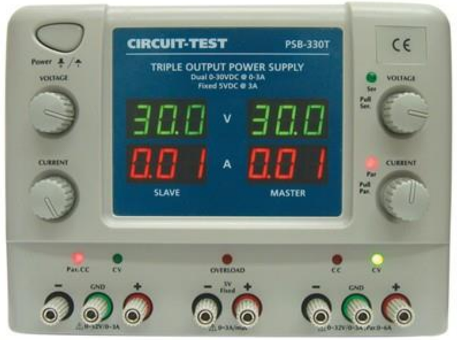


DC (direct current)

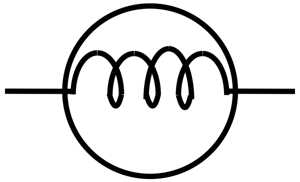


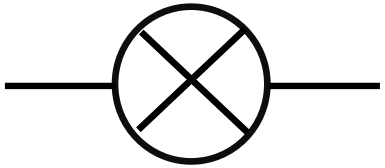
AC (alternating current)



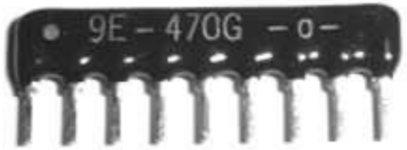


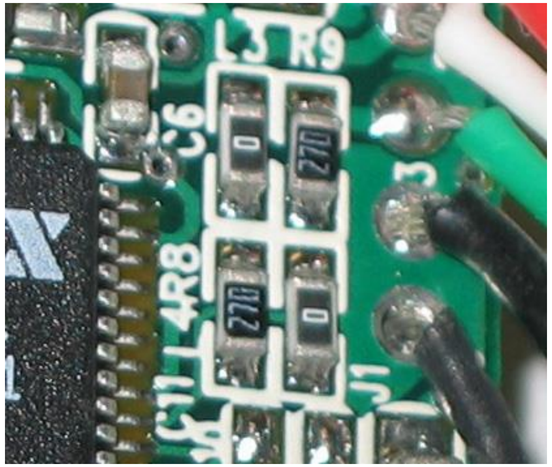
Resistors

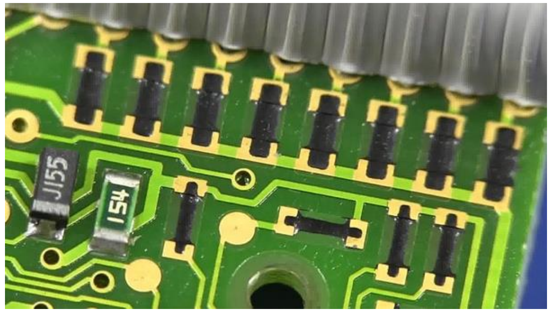


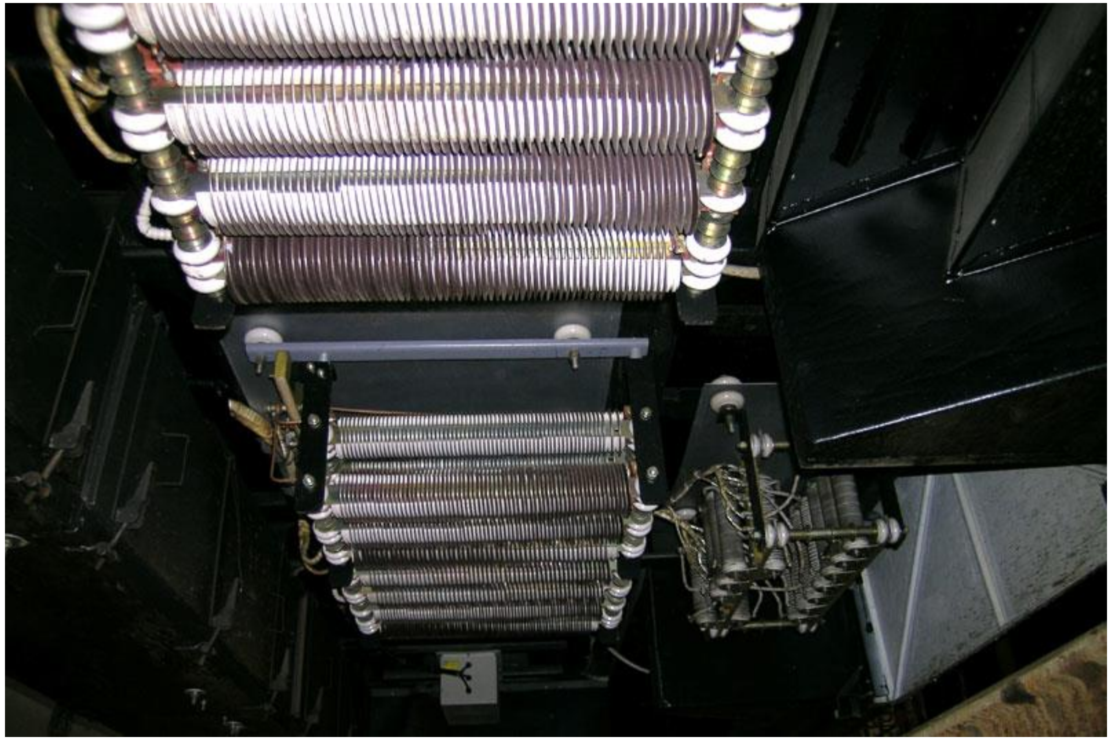


- Consumes power (light bulb)
- Limits the magnitude of electric current

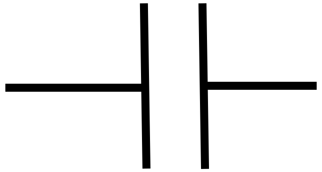




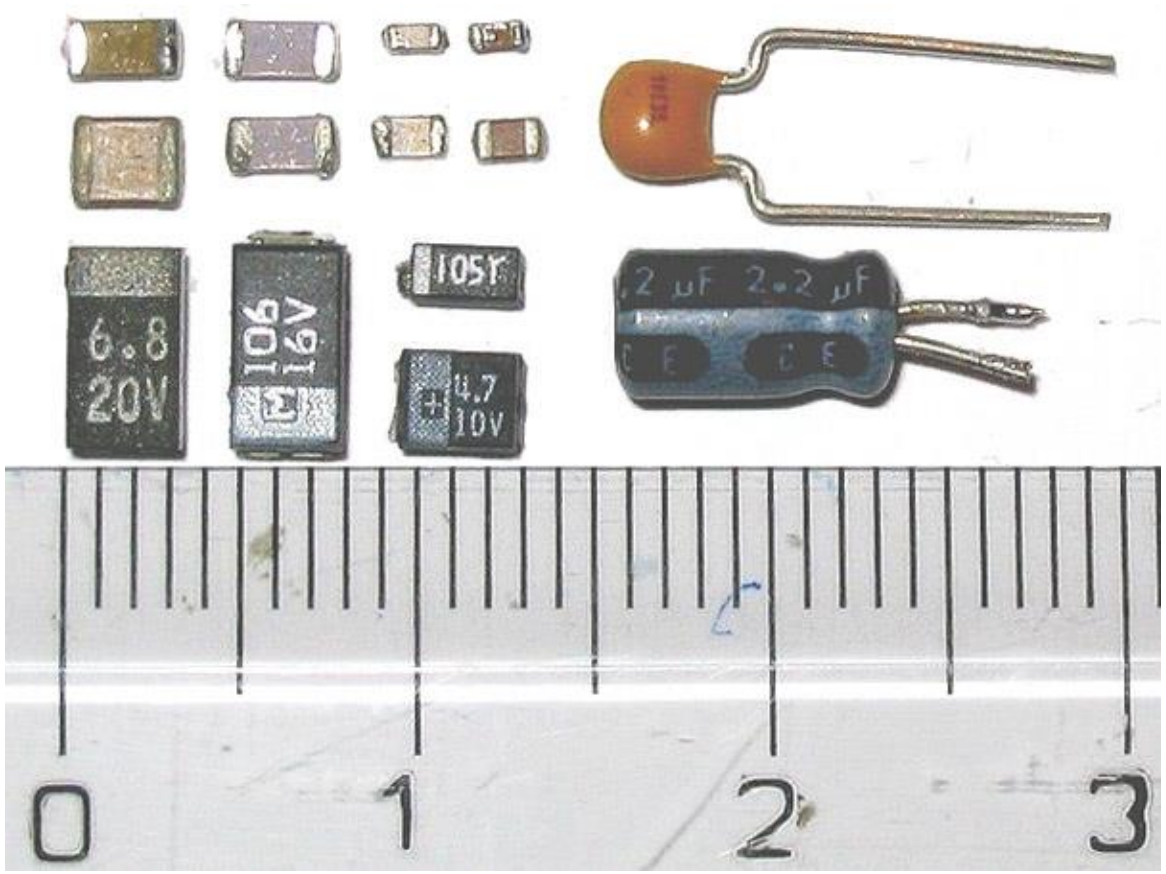




Capacitors



- Device designed to store electric charge and electric energy

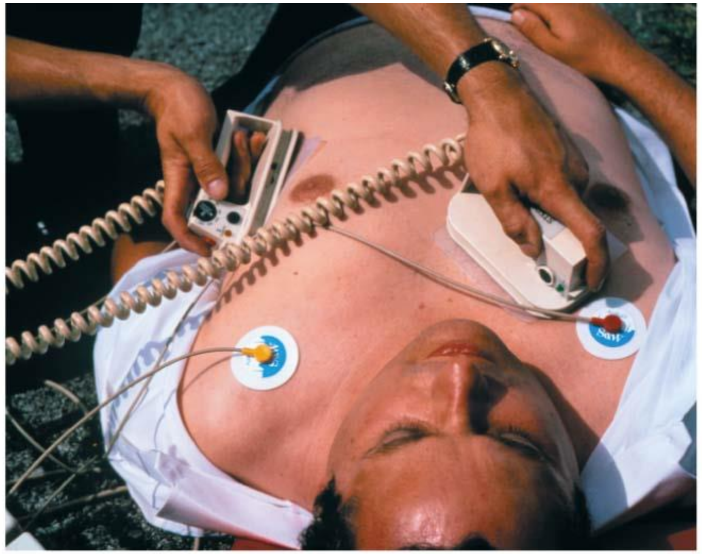


A few applications of capacitors:

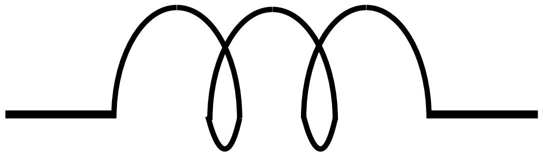
Some touch screens

Fuel gauge

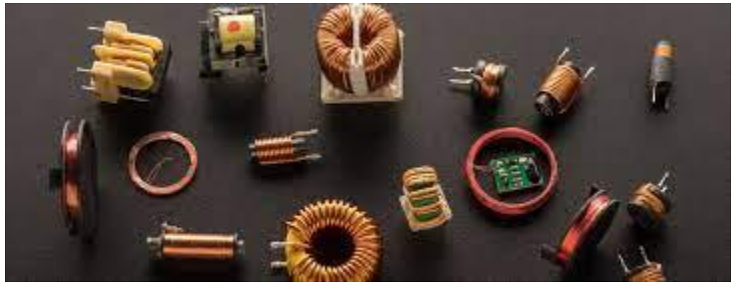

Camera flash


Defibrillator: resorts a normal heartbeat by discharging a capacitor throughout the patient’s chest

Inductors



- Stabilizer: an inductor opposes any change of current that flows through it (by creating “induced current”)

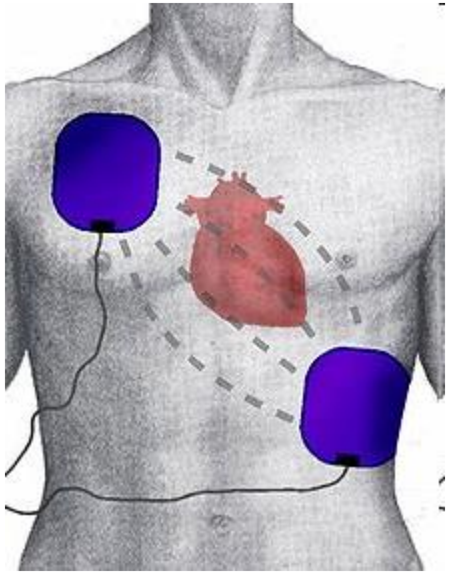


Defibrillator

- Needs to deliver 200 Joules in ~5 ms ($P \sim 40$ kW) in the form of a damped sine wave.

(Not possible with a battery or household electricity).

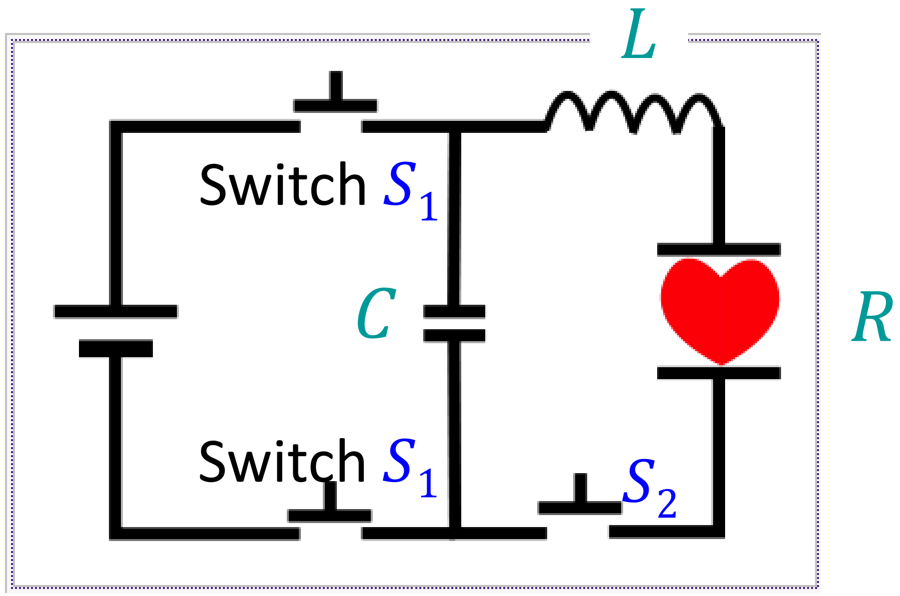
- Based on large capacitor(s) charged to 1000 V.
- Average current is thus 20 – 40 A.



- Electrically, the heart behaves like a resistor.

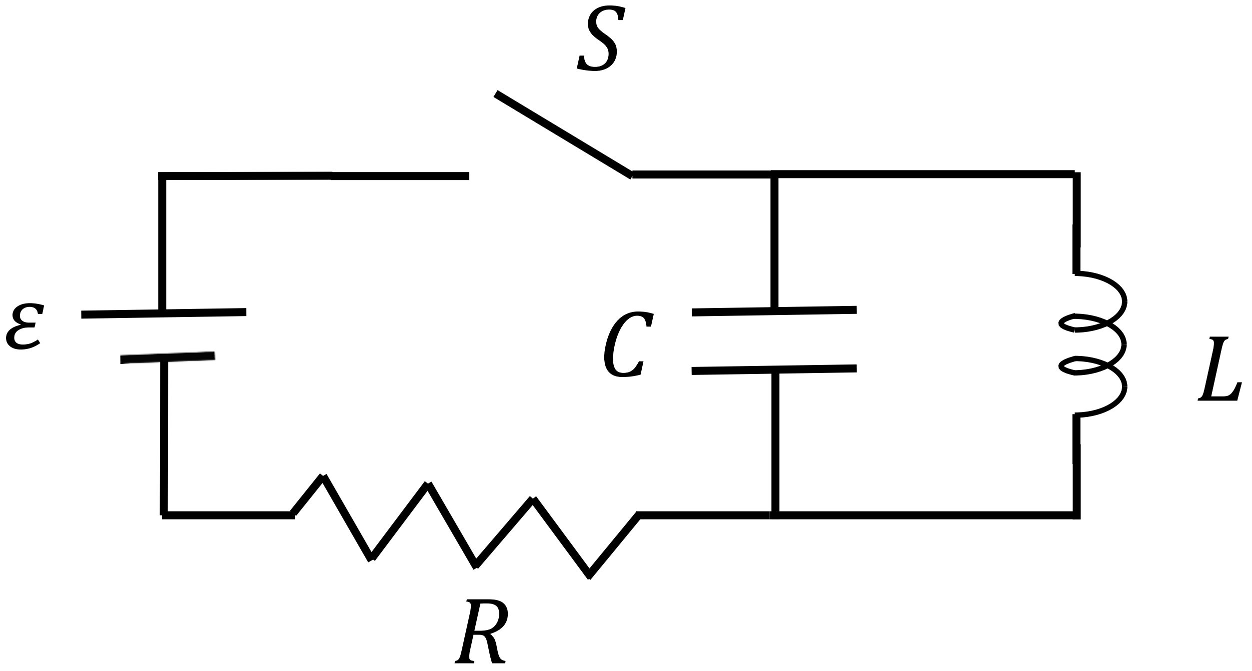
- Switches: S1 is for charging and S2 is for discharging the capacitor.

- The inductor lengthens the discharge time of the capacitor.



Circuit Analysis: Where are we going

- We will start with time-independent circuits, and then will include dynamics (time-dependent circuits – transients)
- At the end this section you will be able to solve this time dependent DC circuit problem



Current, Resistance, Voltage

- We will start with simple circuits with a power source and resistors
- Let's briefly define terms we are going to use

Current I is defined as a flow of $+$ charges: $I = \dfrac{dQ}{dt}$

- Current is created by certain voltage (e.g. produced by a battery)

Resistance, R:

$$R = \frac{\rho L}{A}$$

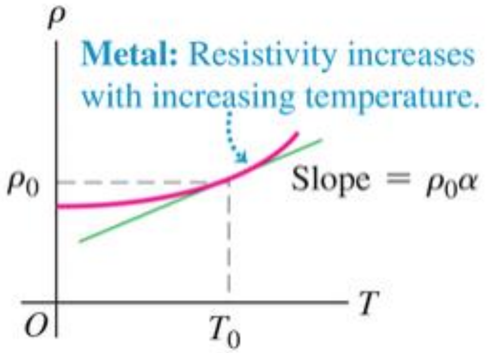
- Resistance = the object ("resistor") resists flow of current
- Appears because charge carriers get scattered by thermal vibrations of the atoms of the resistor, and by impurities
- Depends on the geometry of the resistor (its length L and cross-section area A), and on the "electric responsiveness" of the material (captured by its resistivity ρ)

Resistance, R:

$$R = \frac{\rho L}{A}$$

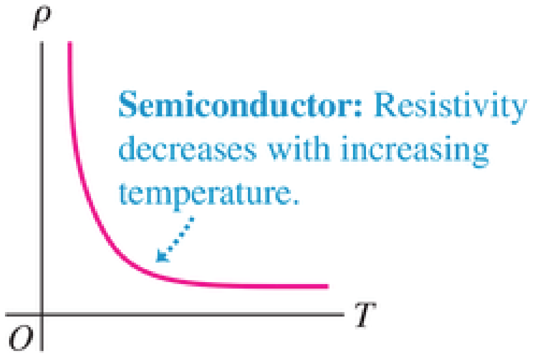
- Appears because charge carriers get scattered by thermal vibrations of the atoms of the resistor and by impurities
- Depends on the geometry of the resistor (its length L and cross-section area A), and on the "electric responsiveness" of the material (captured by its resistivity ρ)
- See Ch 25.2, 25.3 for more detail

Conductors ✓
(metals):
- $\rho \sim 10^{-8}\ \Omega \cdot m$
- $\rho \uparrow$ when $T \uparrow$

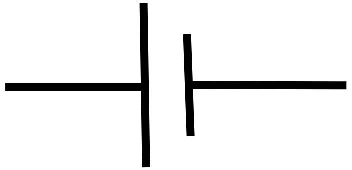


Insulators: ✓
(ex: wood)
- $\rho \sim 10^{8} - 10^{14}\ \Omega \cdot m$
- Do not support I

Semiconductors:
(ex: C, Ge, Si)
- $\rho \sim 10^{-5} - 10^{3}\ \Omega \cdot m$
- $\rho \downarrow$ when $T \uparrow$



Voltage drop for DC circuit components: Summary

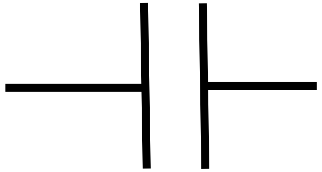


DC power supply / Battery:

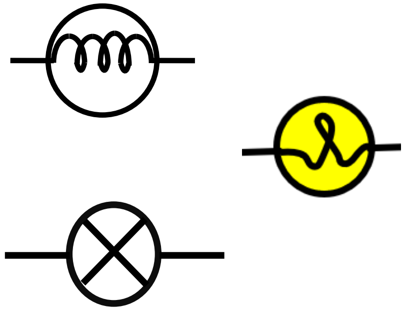
EMF: V or ε

(specified on the battery)

Electromotive force



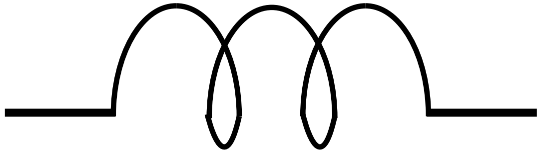
Capacitor: $\Delta V_C = \dfrac{Q}{C}$



Resistor:

$$\Delta V_R = IR$$

(Ohm's law)

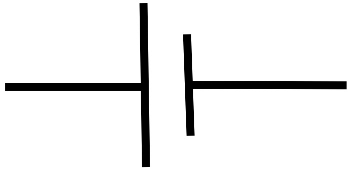


Inductor:

$$\varepsilon_L = -L\, dI/dt$$

"Back EMF"

Voltage drop for DC circuit components: How it works



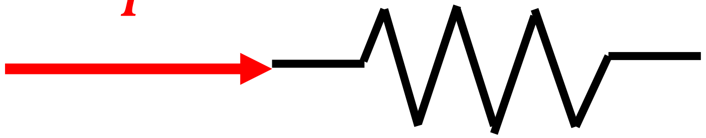
DC power supply / Battery:

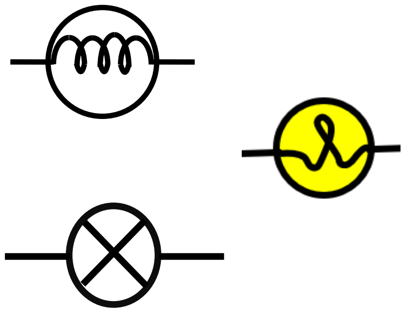
EMF: V or ε

(specified on the battery)

R (resistance)

I



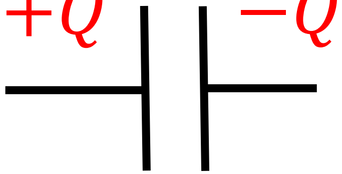


Resistor:

$$\boxed{\Delta V_R = IR}$$

(Ohm's law)

$+Q$ $-Q$

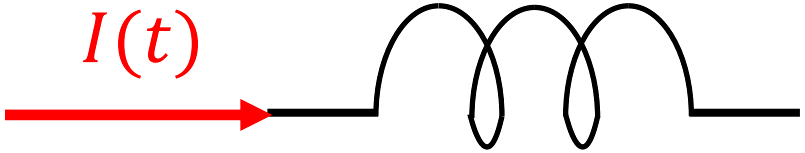


C (capacitance)

Capacitor: $\boxed{\Delta V_C = \dfrac{Q}{C}}$

L (inductance)

$I(t)$



Inductor:

$$\boxed{\varepsilon_L = -L\, dI/dt}$$

"Back EMF"

Voltage drop across a resistor: Ohm's law

$$\boxed{\Delta V_R = IR}$$

Ohm's law

- Assume you have a resistor (lightbulb, heater, toaster -- any R-element)

- Assume a current I flows through this resistor

- Then a voltage $\Delta V_R = IR$ develops across this resistor

  (aka "the voltage drop is proportional to the current").

- The coefficient, R, is called resistance of the resistor.