Electrical and Electronics Circuits (4190.206A 001)

- Lecturer: Prof. Taehyun Kim (301-407), taehyun@snu.ac.kr
- Teaching Assistants
  - Chaewon Kim (kcwchae@gmail.com, 301-416)
  - Seungwoo Yoo (suyoo01@gmail.com, 301-451-1)
  - Kwang Yeul Choi (choi31415@gmail.com, 301-451-1)
- Schedule
  - Class hour: Mon. and Wed. 11:00am~12:15pm / 301-118 (occasionally I will hold an interactive Q&A session using zoom. I will announce the zoom session on ETL later.)
  - Office hour: Wed. 7:00~8:00pm / 301-407 (Please send me an e-mail if you want to have 1-1 meeting online in advance.)
- Textbook: Foundations of Analog and Digital Electronic Circuits, Anant Agarwal and Jeffrey H. Lang, 1st ed. (2005)
  - MIT OCW: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/
- Course homepage: ETL
- Grades: 3 exams 30, 30, 30% homework + attendance: 10% (If you cannot attend the class for official reason, please let me or TA know in advance.)

Prerequisite Background for this Class I

- Engineering mathematics used to be a prerequisite for this class
- Because it is not a mandatory for those students who chose CSE as their double-major or minor, we decided to offer a separate class that teaches how to solve the differential equation during the lecture.
  - However, last year it also turned out that many students didn't learn the basic mathematics that is generally taught at high school for those students who prepares for engineering and science major in college (고등학교 이과).
  - To check if you have those math background for this class, please go to the following survey: https://docs.google.com/forms/d/e/1FAIpQLSfnekGNW2MhMcKIrAoBsZpmU4CjFcBlel9SK8y73zG-SdZaHA/viewform
  - During the regular class, I will assume that you are familiar with the above topics. Therefore, if you are not ready, either study by yourself or our TA will provide an extra online summary lecture in Korean (2~3 hours).

Prerequisite Background for this Class II

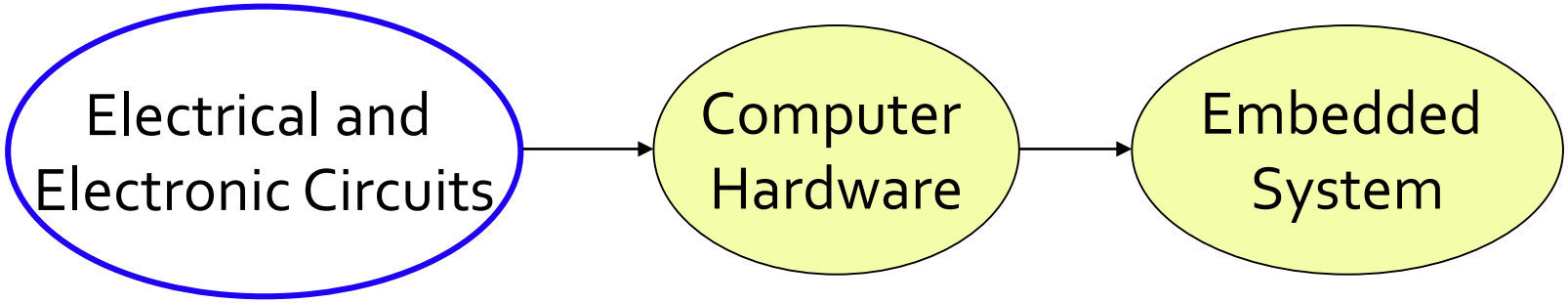
- Many concepts in electric circuit comes from the middle-school level physics.
  - However, last year some students still had hard time in understanding voltage, current, resistance, Ohm's law etc.
  - If you feel that you are not familiar with these concepts, I strongly recommend that you should go back to your middle-school textbook and refresh your memory.
  - With a simple google search, I already found some of the material explaining those for the middle school students.
    - 지학사 중3 전기 지도서
    - 중3 과학 1단원 전기와 자기 문제

      You should at least know "Chap. 02. 전류,전압, 전기저항" and "Chap. 03 – Sect. 3. 전자기 유도" in "전기와 자기 요약.hwp"

      You should be able to solve all the problems in "3-1-2.hwp" and prob. 21~30 in "3-1-3.hwp"
    - http://phys.kongju.ac.kr/abc/03.pdf
  - After reviewing those concepts, if you still have trouble, I might ask one of TAs to deliver an online summary lecture for those concepts, but there should be enough demand (more than 10 students). Please send e-mail to choi31415@gmail.com which part requires summary lecture.

Why Electrical and Electronic Circuit?

- It provides background knowledge to understand how the digital logic works and is a pre-requisite for advanced system courses.



Tentative Schedule

[Week 1] Chap. 1 The Circuit Abstraction

[Week 2] Chap. 2 Resistive Networks

[Week 3] Chap. 3 Network Theorems

[Week 4] Chap. 5 The Digital Abstraction and Chap. 6 The MOSFET Switch

[Week 5] Chap. 4 Analysis of Nonlinear Circuits

[Week 6] Chap. 7 The MOSFET Amplifier, the first mid-term exam

[Week 7] Chap. 7 The MOSFET Amplifier (continued)

Tentative Schedule

- [Week 8] Chap. 9 Energy Storage Elements
- [Week 9] Summary of differential equations
- [Week 10] Summary of differential equations (continued)
- [Week 11] Chap. 10 First-Order Transients in Linear Electrical Networks
- [Week 12] 2nd mid-term exam, Chap. 11 Energy and Power in Digital Circuits
- [Week 13] Chap. 12 Transients in Second-order Circuits
- [Week 14] Chap. 13 Sinusoidal Steady State: Impedance and Frequency Response. Chap. 15 The operational Amplifier Abstraction
- [Week 15] Chap. 15 The operational Amplifier Abstraction (continued), Final exam

Abstraction

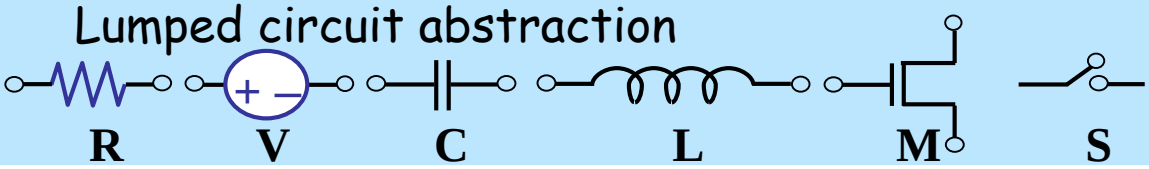
Physics laws or "abstractions"

- Maxwell's
- Ohm's

$V = R I$

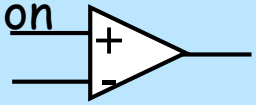
→ abstraction for tables of data

Lumped circuit abstraction

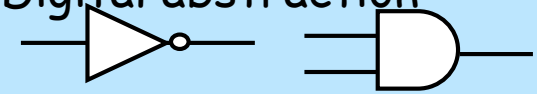


Simple amplifier abstraction

Operational amplifier abstraction abstraction

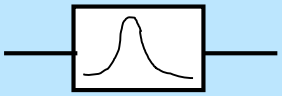


Digital abstraction



Combinational logic

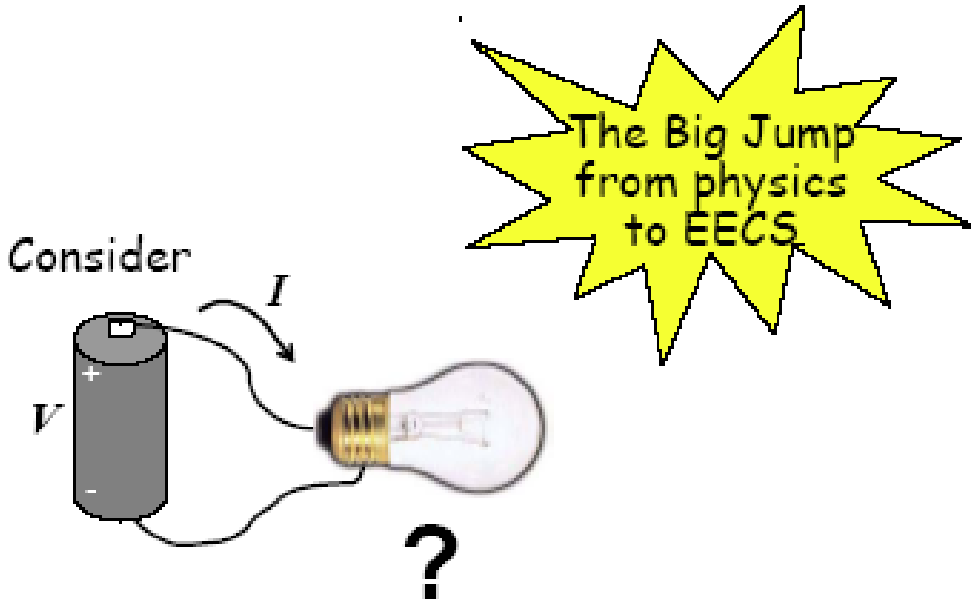
Filters

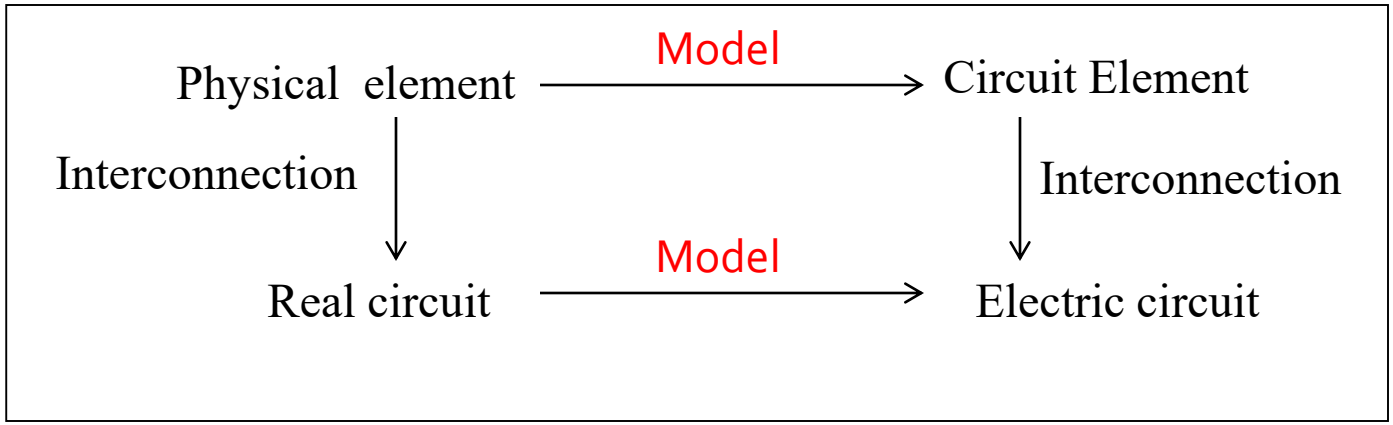


Analog system components: Modulators, oscillators, RF amps, power supplies

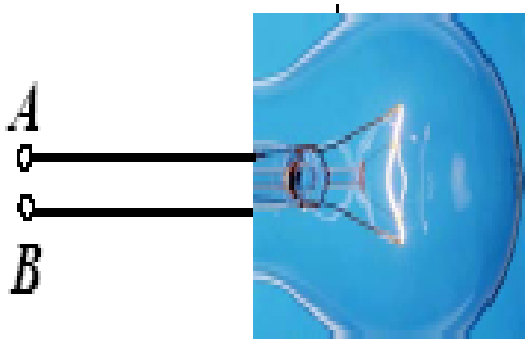
Software systems
Operating systems, Browsers

Lumped Circuit Abstraction

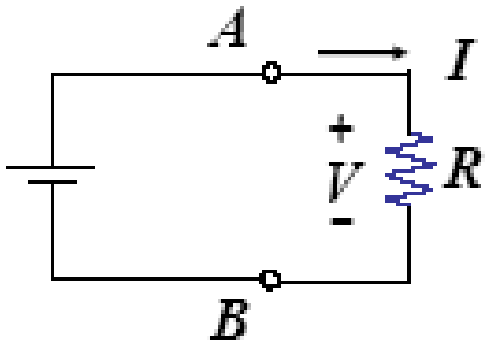




The Easy Way …

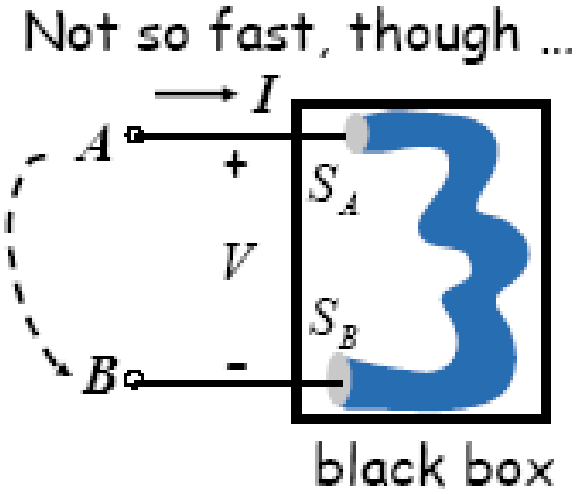


- R is the "lumped circuit abstraction" of the bulb.



and $I = \frac{V}{R}$

Lumped Circuit Abstraction Assumption



- V and I must be defined for the element
- Element behavior is completely captured by its I-V relationship.
- Model each element in terms of functional relation

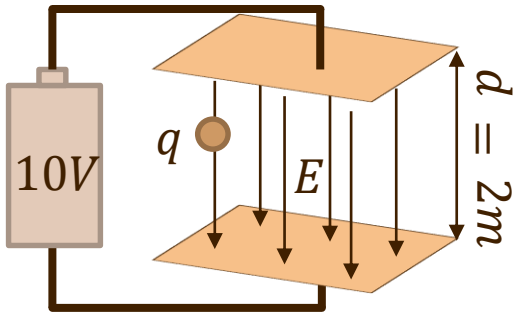
Basic Concepts in Physics

- Work
  - How do you measure the amount of work?
  - Work = Force x Distance
    - Unit of force: N (Newton) ➔ 1N: the weight of ~102 gram mass
    - Unit of work: J (Joule) ➔ 1J: the amount of work to raise a mass of 102 gram by 1 meter
  - Direction matters!
  - Positive work vs. negative work

- Power
  - Amount of work done per unit time
  - Unit of power: W (watt) ➔ 1W: 1Joule per 1 second

Basic Concepts in Physics

- Charge
  - SI unit for charge is Coulomb, and written as C.
  - 1C: the amount of charge of ~6.2×10^{18} electrons



- Voltage
  - What do mean by 1.5V battery?
  - For simplicity, assume $10(V)$.
  - If the distance d is 2 meter, the electric field strength E is $5(V/m)$.
  - If we place a test charge $q = 3C$ inside the electric field, then the force F experienced by the test charge q due to the electric field E is $F = q \cdot E = 3(C) \times 5(V/m) = 15(N)$
  - Work done by the electric field: $\Delta W = F \cdot d = qdE = 30(J)$
  - Voltage is a work to be done on a unit charge: $V = \Delta W/q = Ed$