CSCI 2461: Lab 1

- Introductions
- Review Binary Representation
- Quick Physics Review

1

Who are we ?

- Sam Kusner
- Kate Halushka
- Karl Simon

- Ruining Yang

- Lauren Hahn
- Jonathan Lee

2

What to expect in this course ?
Our experience

3

Today's Lab session

- 1. Review lecture on Binary Representation ….Questions ?
- 2. Quick review of Physics (needed for circuit design)

4

5

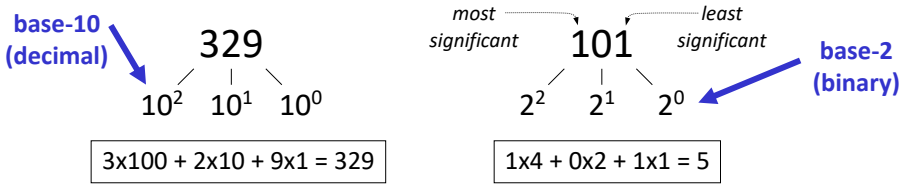
(Unsigned) Integer Representation

- Non-positional notation (unary): 5 represented as 11111
- What are you used to ? Decimal representation (0..9) and…
- Decimal **Weighted positional representation**
  - *Position gives the weight of the location*
- Extend to any base, including binary…..
  - Weights in decimal are 10^0, 10^1 , 10^2 , 10^3, …
  - Weights in binary are 2^0, 2^1, 2^2, 2^3,….

6

Integer Representation

- Weighted positional representation in Binary



Notations: the bit position i has weight of 2^i
n bit binary number $a_{n-1}a_{n-2},\ldots,a_1,a_0$

represents the decimal value/number

$$\sum_{i=0}^{i=n-1} a_i\, 2^i$$

7

Questions

- what decimal number does the binary string 11001 represent
- What decimal number does 00110 represent ?

8

Decimal to Binary Conversion:

1. What is the binary representation of decimal number 19
   - Express 19 as a sum of numbers each a power of 2
   - Algorithm to convert decimal (base 10) to binary (base 2)
     - Generalize to convert from base k to base m

k bit number: $b_{k-1}, b_{k-2}, \ldots, b_1, b_0$

Decimal integer N represented by this binary number is:

$$b_{k-1}\,2^{k-1} + b_{k-2}\,2^{k-2} + \ldots + b_1\,2^1 + b_0\,2^0$$

19 = 1.16 + 0.8 + 0.4 + 1.2 + 1.1

= **1**.2^4 + **0**.2^3 +**0**.2^2+ **1**.2^1 + **1**.2^0

10011

9

Conversion from Decimal to Binary

```
//input is Decimal number N, output is list of bits b_i //
i=0;
while N > 0 do
   b_i = N % 2; // b_i = remainder; N mod 2
    N = N / 2; // N becomes quotient of division
    i++;
end while /* replace 2 by k and your algo can convert to any base k */
```

- Iteration i=0: b_0 = 19%2 =1 and N= 19/2= 9
- Iteration 1: b_1 = 9%2 = 1 and N=4
- Iteration 2: b_2 = 4%2 = 0 and N=2
- Iteration 3: b_3 = 2%2 =0 and N=1
- Iteration 4: b_4 = 1%2 =1 and N=0 so loop terminates
- Binary representation of 19 = 10011

10

Questions

- What is the binary representation of 11

- What is the binary representation of 23

11

Quick Physics Review
Why ? we need a bit of this to study digital logic circuits

- Basics of electricity:
- Voltage
- Current
- Resistance

- Ohm's law

12

Let's start with a river….

- Water always flows from high elevation to low elevation
- Speed of the water flow is dependent on:
  - Steepness of the slope/height of the source
  - Obstructions in the river's path that resist the flow of water
- The height difference is a type of "potential" energy
  - Higher the start of the river the greater the flow/pressure
  - A voltage difference analogous to an elevation difference in a waterfall – water flows from higher elevation to lower elevation

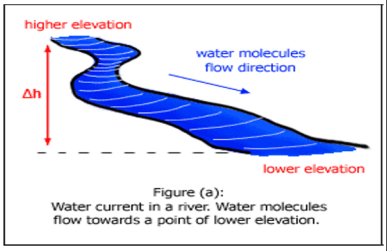
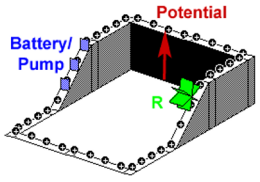


Figure (a):
Water current in a river. Water molecules flow towards a point of lower elevation.

13

Voltage

- Measured in Volts – symbol for voltage is V
- Always measure relative to some baseline (usually "ground" or 0 volts)
- Battery is most common source of voltage
  - Analogous to a "pump" that releases electricity into a circuit at a certain voltage (potential/ height)
- Conventionally, electicity moves from high voltage (+ve) to low voltage (-ve)
  - Electrons flow from –ve to +ve
- A voltage difference between 2 points captures the amount of work it would take to move charge from one point to another
  - analogous to an elevation difference in a waterfall



14

Current and Resistance

- Current: A measurement of the flow of electricity, i.e., "how fast" it's going
  - Flow of electrons
  - Measured in Amperes (amps) – symbol is I
- Resistance: opposes the flow (of electricity)
  - Measured in Ohm's – symbol is R
  - Resistor = common electrical component that offers resistance in circuit

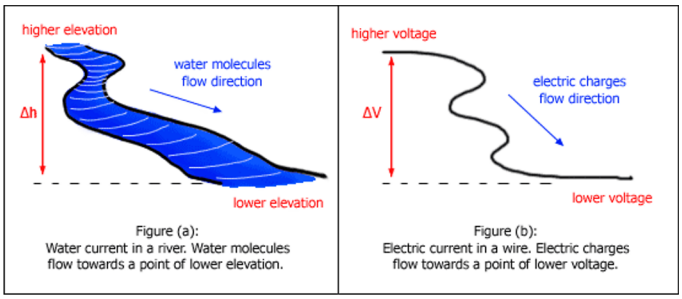


Figure (a):
Water current in a river. Water molecules flow towards a point of lower elevation.

Figure (b):
Electric current in a wire. Electric charges flow towards a point of lower voltage.

15

Ohm's Law

- Voltage, Current, Resistance in a circuit are closely related
  - More voltage = more current flow
  - More resistance = less current flow
    - But we can add voltage to increase current !
- Ohm's Law: formula to describe the voltage-current-resistance relationship

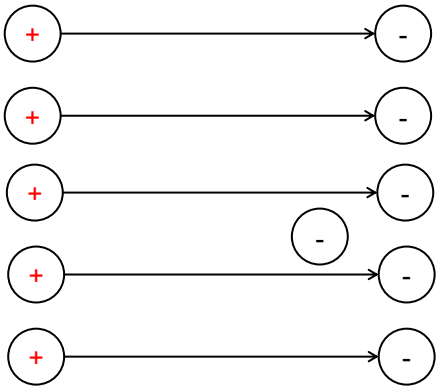
$$V = I*R$$

  - You can also solve
  - current $I = V/R$
  - Resistance $R = V/I$
  - Note if R is infinity (very large) then current = 0 !

16

Voltage/Current and Electric Field

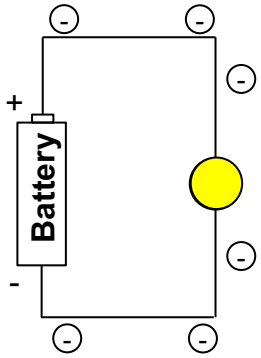
E-field produces "potential difference"
Aka: motivation for charge to flow



Direction of charge carrier (e-)

Direction of current

Battery provide voltage
Aka: potential difference



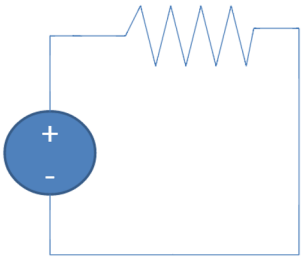
Direction of current

Ohm's Law: V = IR

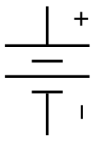
17

Looking at a circuit diagram

- Do we know which way the electricity flows ?



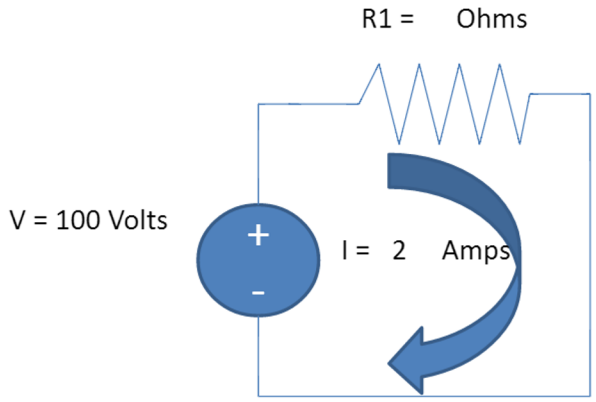
*Usual symbol for battery:



18

Example Problem 1:

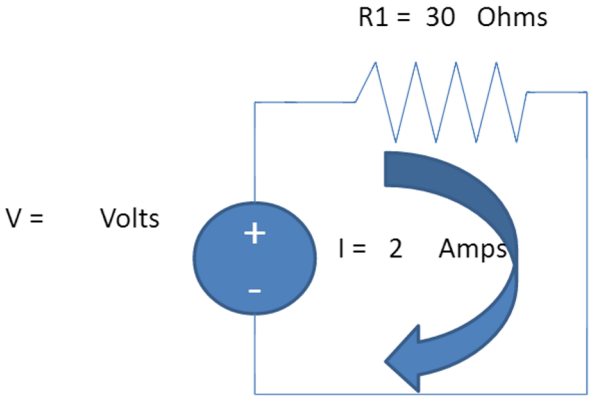
- What is the value of R1 ?
- Recall Ohm's law V = IR



19

Example Problem 2

- What is the value of V ?



20

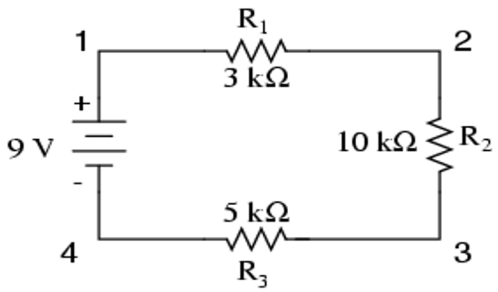
More circuit theory…..

- Types of Circuits
  - Series
  - Parallel

21

What is a “series” circuit ?

- When components are placed one after another (ex: some Christmas lights)
- Characteristic: the current at all points will be the same
  - $I_1 = I_2 = I_3$
  - Electricity does not “build up” in front of R_1 because the current is slowed to the same speed at all points



22

"Series" circuits

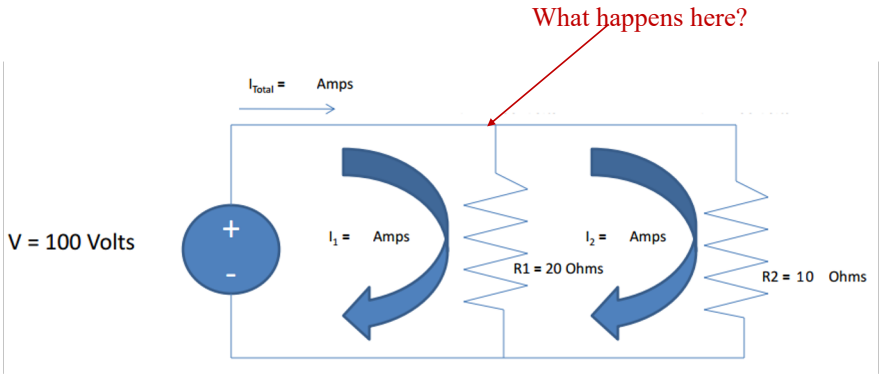
- Voltage sources in series are added together
  - 2*1.5 = 3.0V

- ..and so do resistances

23

What is a "parallel" circuit

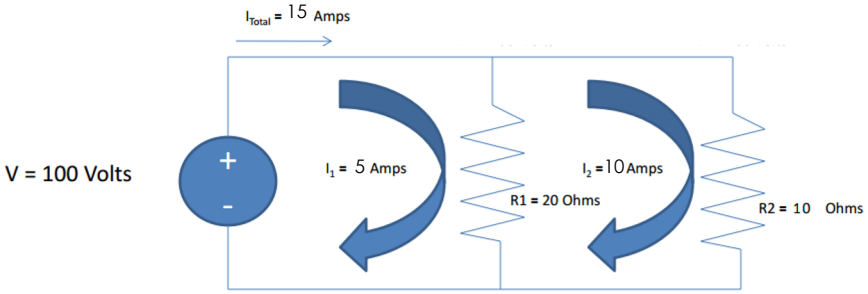
- Anytime we have multiple paths for electricity to follow (i.e., forks in the road!)
- So, we need to know how forks affect our voltage and current….



24

Path of least resistance

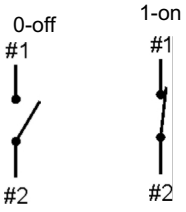
- Current flowing through each branch is proportional to the resistance
  - i.e., we see more current (double) flowing throught R_2 than R_1
- *Question: What if R_1 = infinity ? Does any current flow through it*



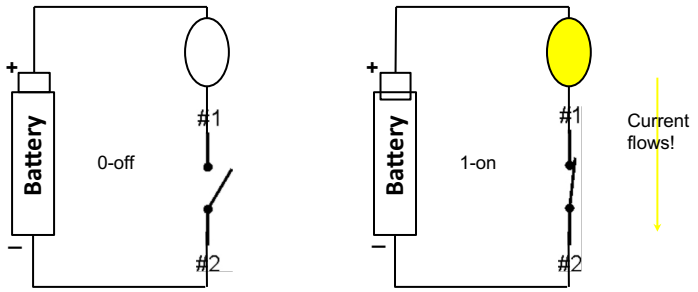
25

Switches (very relevant to us!)

- A switch inherently represents two states: ON/OFF (closed/open)
  - Interpret ON=1 and OFF=0 and we have binary!



- When switches are put in a circuit, can start/stop current flow

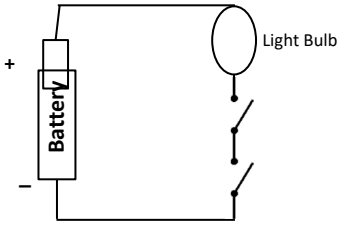


26

Switches and Series/Parallel Circuits

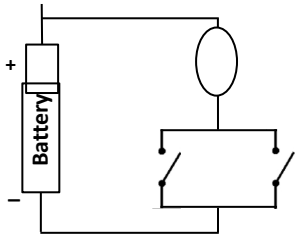
- Putting multiple switches in a circuit (replace resistors with switches)

Switches are in series



Both switches must be "on" for bulb to light up (AND)

Switches are in Parallel

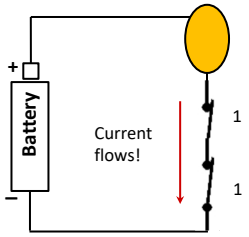


Only 1 switch Must be "on" for Bulb to light up (OR)

27

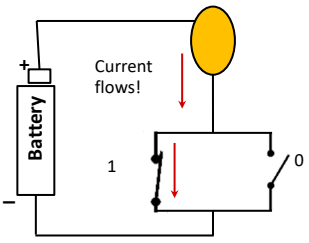
Switches and Series/Parallel Circuits

Switches are in series



Both switches must be "on" for current to flow from + to - (for bulb to light up) (AND)

Switches are in Parallel



Only 1 switch must be "on" for current to flow from + to - (for bulb to light up) (OR)

28

Series & Parallel Circuits: Key takeaway

- Series circuits: resistance adds up and there is still only one path from +ve to –ve.
- Current flows through each of the parallel circuits from Voltage source (battery +) to voltage ground (battery - ve).
  - More current flows through circuit with lower resistance…path of least resistance!!
- In context of switches (instead of resistors):
  - **Parallel Circuits: Current flows if at least one of the switches is closed/ON**
    - **No current flows if ALL switches are open/OFF**
  - **Series Circuits: Current flows if ALL switches are ON**
    - **No current flows if at least one switch if OFF**

29

Questions ?

30