CSCI 2461- Arch. Lab 1

INTRODUCTION TO ELECTRONICS & WHAT'S IN YOUR H/W KIT

1

Introduction

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2

What Are We Covering Today?

- Basics of Electricity
  - Voltage
  - Current
  - Resistance
- What's in your H/W Kit
- Building a simple circuit

3

Lab Kits logistics

Distribute tool kits

Your Project and Course final grade will be posted only after your return your complete tool kit

this is part of the project requirement

Create simple circuit

4

Basics of Electricity

VOLTAGE, CURRENT, RESISTANCE, OHM'S LAW

5

Let's Start With A River…

6

Let's Start With A River…

Water always flows from high elevation to low elevation.

Speed of the water flow is dependent on:

- The steepness of the slope // the height of the source.
- Obstructions in the river's path resist the flow of water

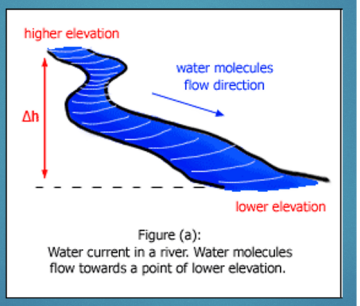
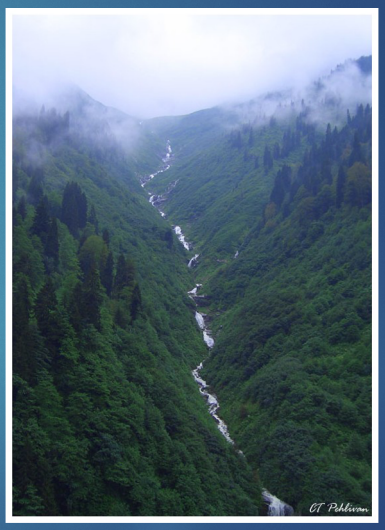


Figure (a):
Water current in a river. Water molecules flow towards a point of lower elevation.



7

How does this relate?

How do we measure height? It's always relative to some "base"

- When we say a person is 6 feet tall, it's implied that the floor is used as the baseline.

We can also look at height as a type of "potential energy"

- The higher the river, the greater the water flow / pressure.
- Or, like a waterfall at different heights.

Voltage is the electrical measurement of potential energy or "pressure".

- Greater voltage → greater electrical energy → more work can be done
- Always measured relative to some baseline (usually "ground" or 0 volts)

8

Voltage

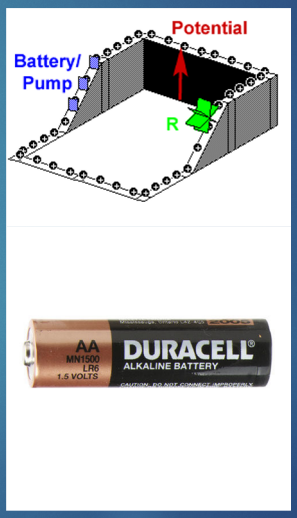
Measured in Volts. Symbol for voltage is V.

The battery is the most common source of voltage.

- Can be thought of similar to a "pump" that releases electricity into a circuit at a certain voltage (potential / height).

Conventionally, electricity moves from high voltage (+) to low voltage (-)

- *electrons flow from -ve to +ve*



9

Current

A measurement of the flow of the electricity // "how fast" it's going.

Measured in Amperes (Amps). Symbol for current is `I`.

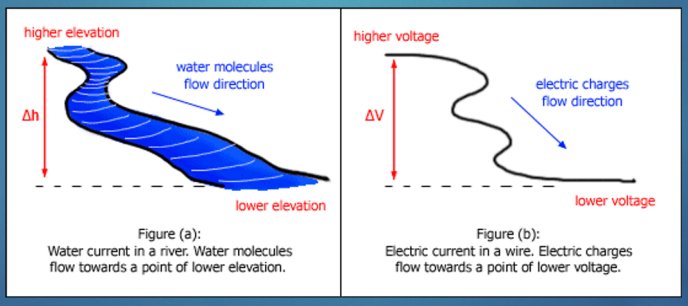


Figure (a):
Water current in a river. Water molecules flow towards a point of lower elevation.

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

10

Resistance

Opposes the flow of electricity.

Measured in Ohms (Ω). Symbol for resistance is R.

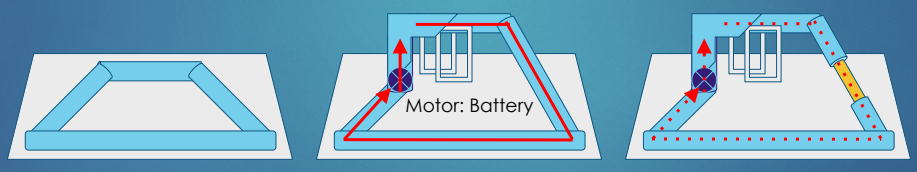
Resistor – a common electrical component that offers resistance in a circuit.

11

Voltage, Current, and Resistance

The three are all very closely related:

- More voltage = more current flow
- More resistance = less current flow
  - But… we can add more voltage to increase current



No "voltage":
Current (I) = 0

Adding "voltage":
Current (I) > 0

Adding resistance

12

Ohm's Law

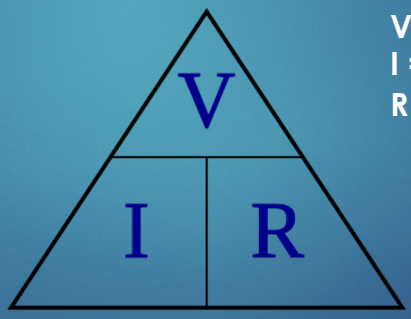
Ohm's Law is a formula to describe the voltage-current-resistance relationship.

V = I * R

You can also solve:

I = V/R

R = V/I

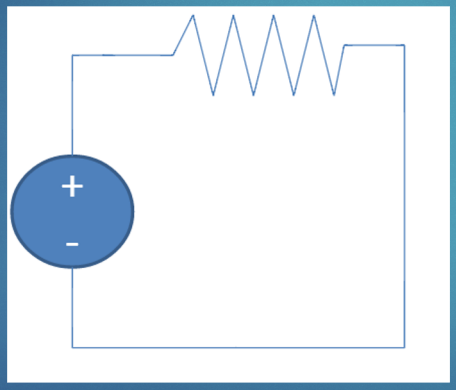


V = Volts
I = Amps
R = Ohms

13

Looking At A Circuit Diagram

Do we know which way the electricity flows?

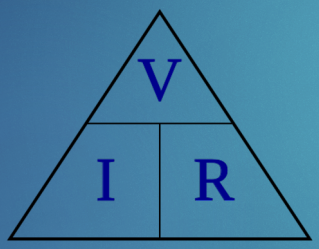


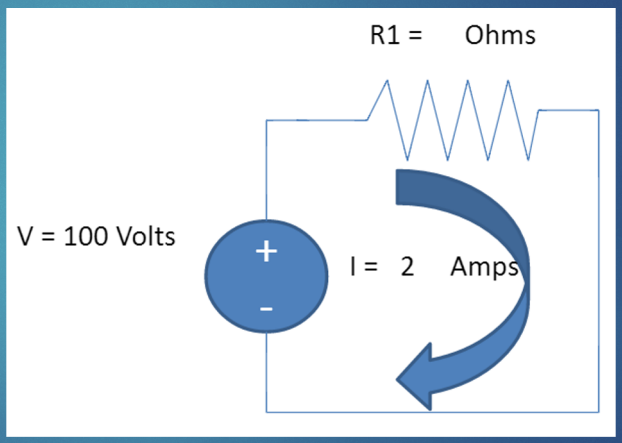
*Usual symbol for battery:

14

Example Problem #1

What is the value of R1?

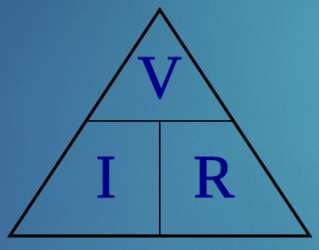


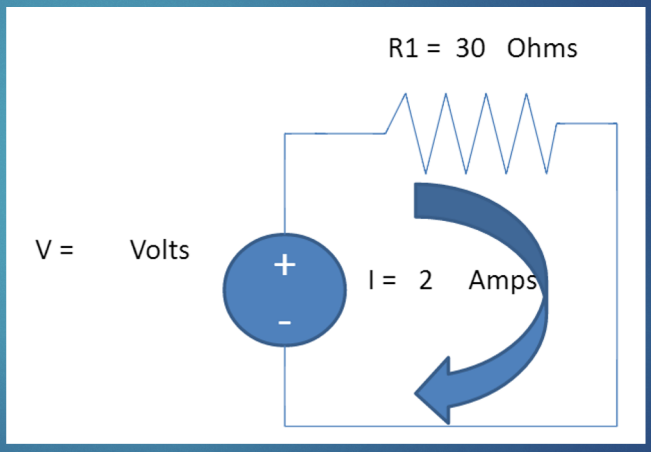


15

Example Problem #2

What is the value of V?





16

More circuit theory….

Types of Circuits

SERIES and PARALLEL CIRCUITS

17

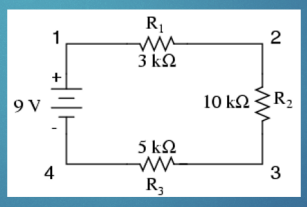
What is a "series" circuit?

When components are placed one-after-another (ex. Christmas lights).

Characteristic: the current at all points will be the same

$I_1 = I_2 = I_3 = I_4$

Electricity does *not* "build up" in front of R_1 because the current is slowed to the same speed at all points.



Visualization: http://www.falstad.com/circuit/

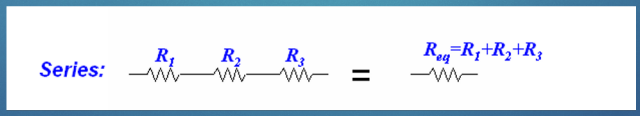
18

What is a "series" circuit?

Voltage sources in series are added together

2 * 1.5 V = 3.0 V

… and so do resistances!

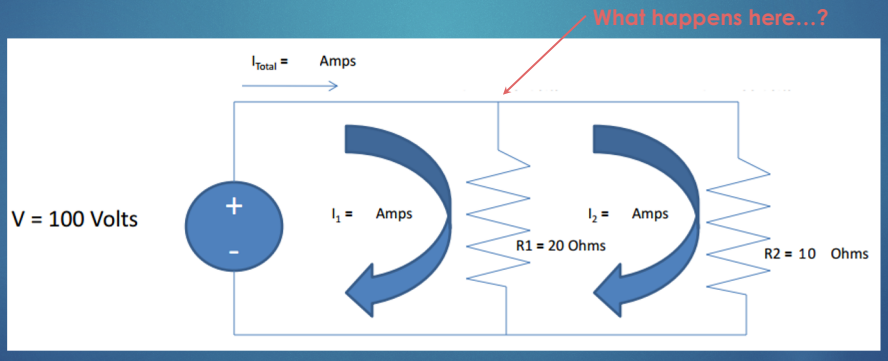


19

What is a "parallel" circuit?

Anytime we have multiple paths for electricity to follow (i.e. forks)

So, we need to know how forks affect our voltage and current…

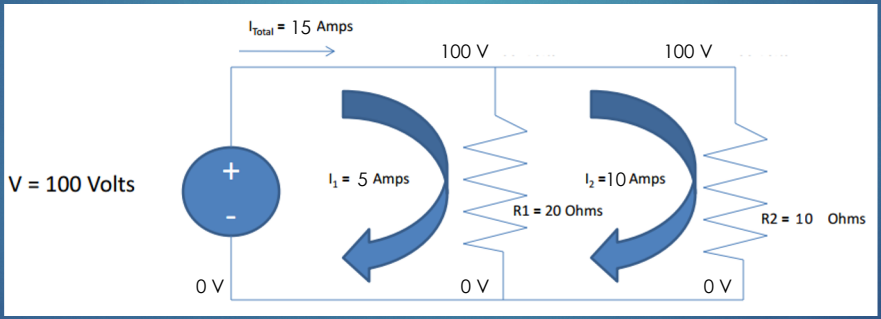


20

Path of Least Resistance

Current flowing through each branch is proportional to the resistance.

i.e. We see more current (double) flowing through R_2 than R_1.

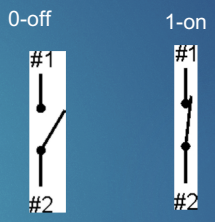


21

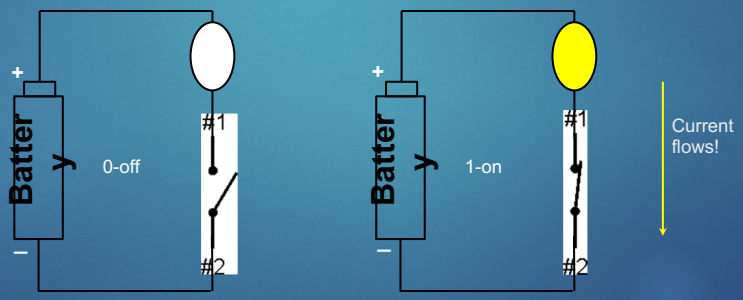
Switches

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

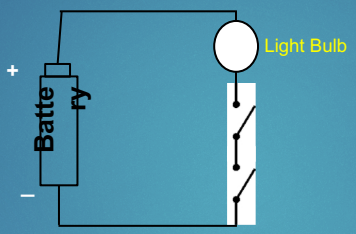


22

Switches and Series/Parallel Circuits

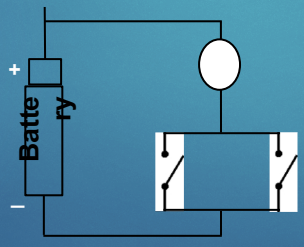
Putting multiple switches in a circuit (replace resistors with switches)

Switches are in series



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

Switches are in Parallel

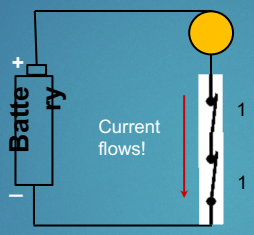


Only 1 switch Must be "on" for Bulb to light up (OR ?)

23

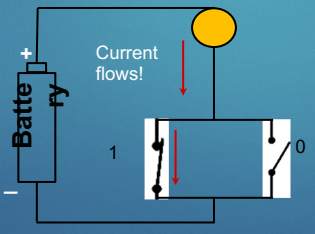
Switches and Series/Parallel Circuits

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)

24

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**

25

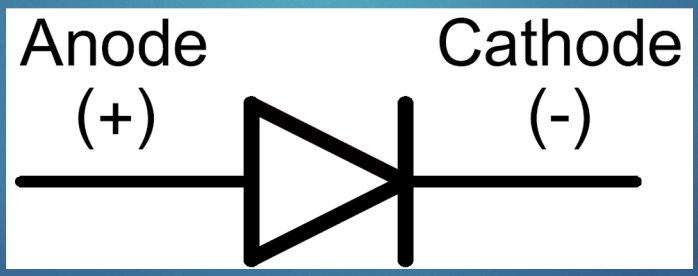
Lab components

26

The Diode

A diode is a component that only allows electricity to flow in one direction (from the anode to the cathode)

Pneumonic: A+ and C -



27

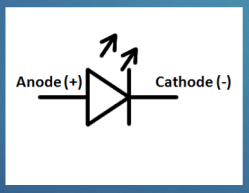
The Light-Emitting Diode

A LED is simply a diode that produces light when electrons flow through it.

Important: LEDs can only take so much current or they can be damaged.

What can we do to limit current flow?

LEDs also drop voltage as they give off light (the "forward voltage")



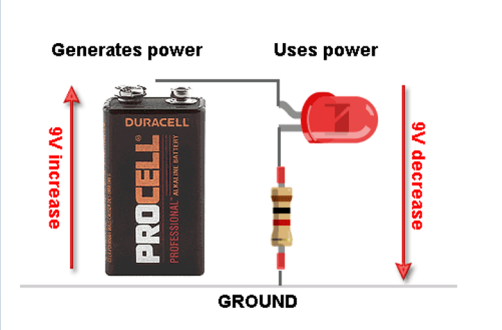
Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
λpeak	Peak Wavelength	High Efficiency Red	627		nm	IF=20mA
λD [1]	Dominant Wavelength	High Efficiency Red	625		nm	IF=20mA
Δλ1/2	Spectral Line Half-width	High Efficiency Red	45		nm	IF=20mA
C	Capacitance	High Efficiency Red	15		pF	VF=0V;f=1MHz
VF [2]	Forward Voltage	High Efficiency Red	2	2.5	V	IF=20mA
IR	Reverse Current	High Efficiency Red		10	uA	VR=5V

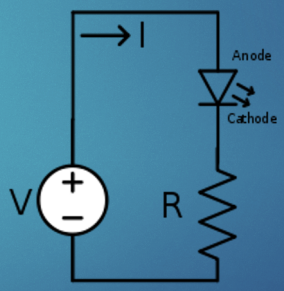
28

Wiring the LED

The longer "leg" of the LED is the anode (+).

We'll need a power supply and some way to put wires together…and always have a resistor in the path

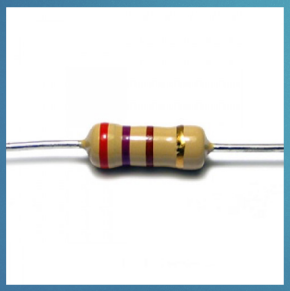




29

How To "Read" A Resistor

The common 4-band resistor has four colors which tell you how much resistance the resistor offers.



30

How To "Read" A Resistor

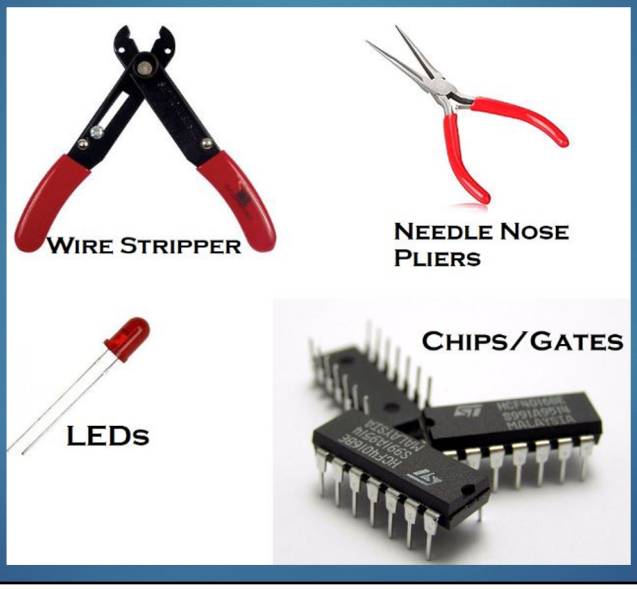
The first two bands make a 2-digit number. The 3rd band tells you the power of 10 to multiply it by. The 4th band gives you a % accuracy.

4 Band Resistor Color Coding

COLOR	1ST BAND	2ND BAND	MULTIPLIER	TOLERANCE
BLACK	0	0	x1Ω	
BROWN	1	1	x10Ω	±1%
RED	2	2	x100Ω	±2%
ORANGE	3	3	x1000Ω	
YELLOW	4	4	x10000Ω	
GREEN	5	5	x100000Ω	±0.5%
BLUE	6	6	x1000000Ω	±0.25
VIOLET	7	7	x10000000Ω	±0.10
GREY	8	8		±0.05
WHITE	9	9		
GOLD			0.1	±5%
SILVER			0.01	±10%

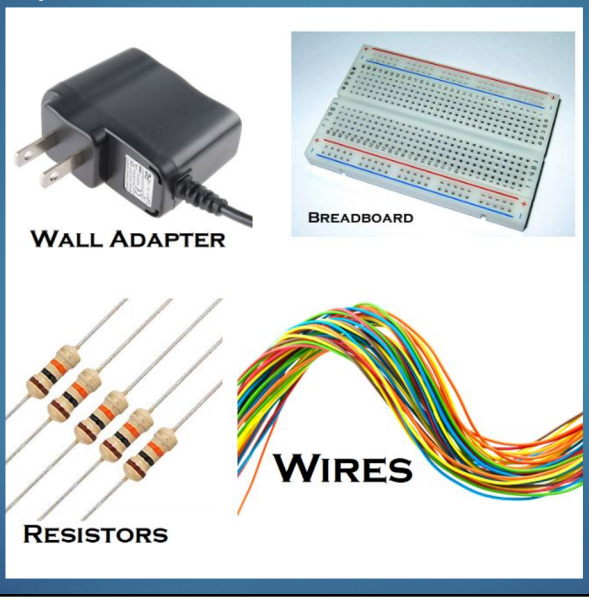
31

Kit Components



32

Kit Components



33

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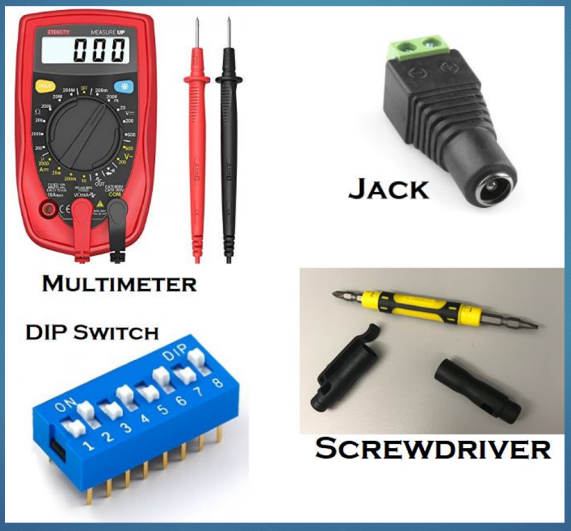
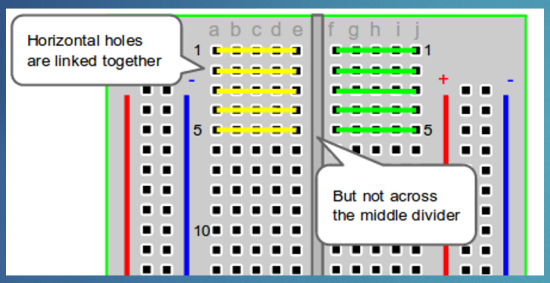
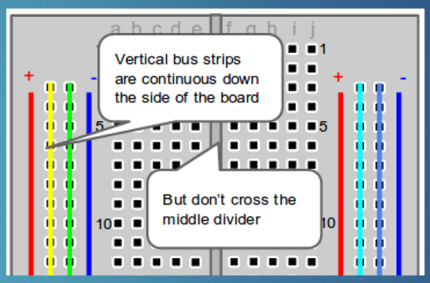


34

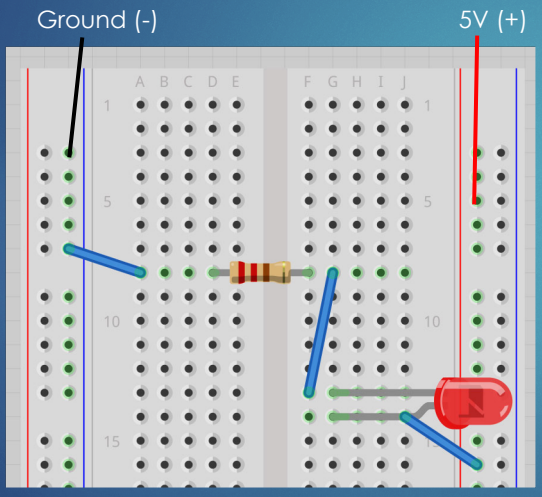
The Breadboard





35

Simple circuit: LED Light



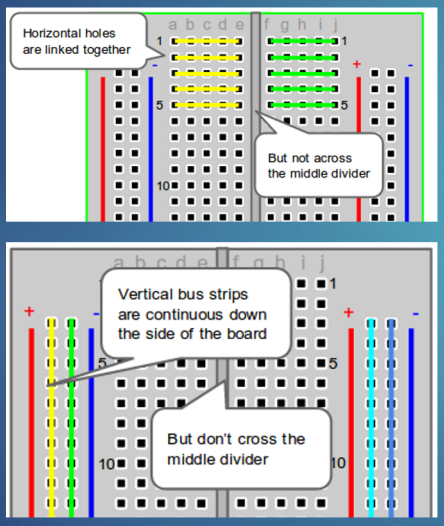
Tips

- **Build your circuit BEFORE giving it power!**
- The long leg of the LED must be connected to power.
- The resistor can be placed *before* or *after* the LED.
- Use a resistor with the color band pattern: Orange Orange Brown Gold (or Blue Blue Brown Gold/any)
- Plug the power supply into a plug point

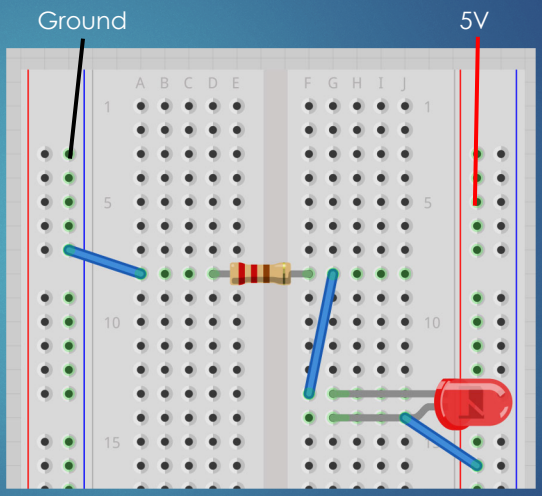
Alert instruction team when you are done so they can check your demo

36

The Breadboard



Simple Circuit



37

Using a Multimeter – next lab

A multimeter is a useful "debugging" tool for circuits.

To measure voltage between two points:

Switch the dial to V and measure the two points.

To measure current:

The two meter leads must be introduced into the circuit – the meter must become part of the circuit (can remove one wire and touch the two meter leads to reconnect the circuit).

To measure resistance:

Disconnect the circuit from power and touch the two leads to the two points you want to measure resistance between.

38

Questions?

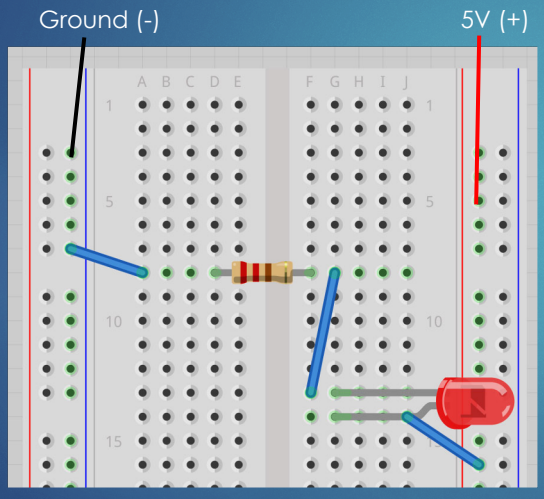
Feel free to email TAs with any questions:

Good resources if you want to learn more:

- http://www.allaboutcircuits.com/textbook/
  - Great explanations of the basics, more series / parallel circuit examples, and higher level knowledge.
- https://learn.sparkfun.com/tutorials/voltage-current-resistance-and-ohms-law
  - Reinforcing the basics (also good site to buy electronic components)
- https://learn.adafruit.com/all-about-leds/overview
  - Overview of wiring LEDs and how to calculate the "optimal" resistor to use.
  - Another guide: http://dangerousprototypes.com/docs/Basic_Light_Emitting_Diode_guide
- https://kaiserscience.wordpress.com/physics/electromagnetism/electric-current/
  - Lots of animations to explain electricity concepts.

39

Lab Exercise: Simple circuit



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- Use a resistor with the color band pattern: Orange Orange Brown Gold (or Blue Blue Brown Gold/any)
- Finally, Plug the power supply into a plug point

Alert instruction team when you are done so they can check your demo
Keep the circuit "as is" for next class

40

More circuit theory….

41

Types of Circuits

SERIES and PARALLEL CIRCUITS

42

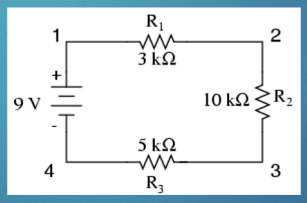
What is a "series" circuit?

When components are placed one-after-another (ex. Christmas lights).

Characteristic: the current at all points will be the same

$I_1 = I_2 = I_3 = I_4$

Electricity does *not* "build up" in front of R_1 because the current is slowed to the same speed at all points.



Visualization: http://www.falstad.com/circuit/

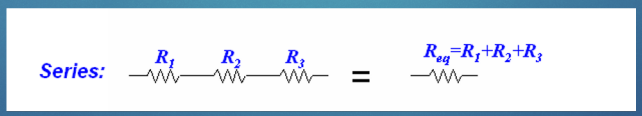
43

What is a "series" circuit?

Voltage sources in series are added together

2 * 1.5 V = 3.0 V

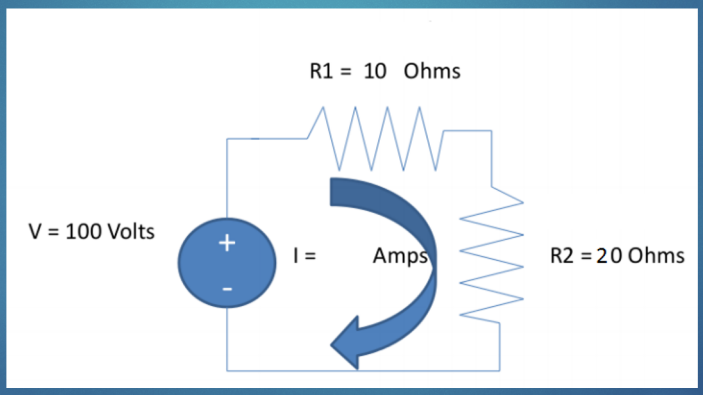
… and so do resistances!



44

Now we can solve this one!

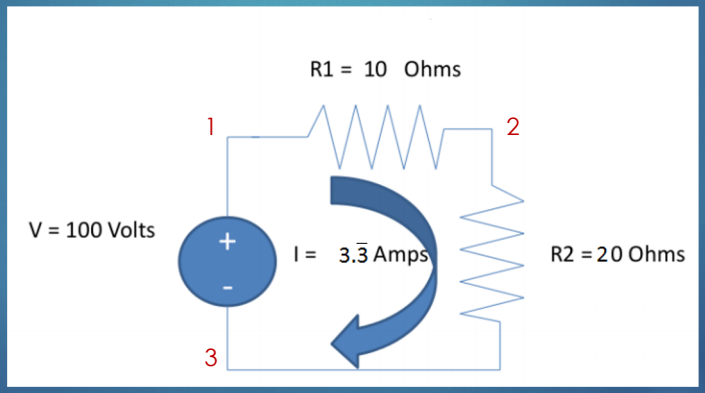
What is the current in this circuit?



45

But what about voltages?

We know that the voltage at Point 1 is 100V and at Point 3 is 0V, but what about point 2?



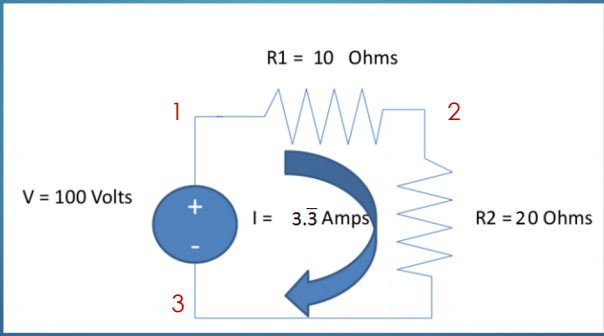
46

Kirchoff's Voltage Law

Each resistor "uses up" some of the voltage – known as a voltage drop.

Law: the sum of all voltage drops == the supply voltage (100V)

i.e. the differences in voltage between points 1, 2, and 3 add up to 100V.



47

Getting Ready To Solve…

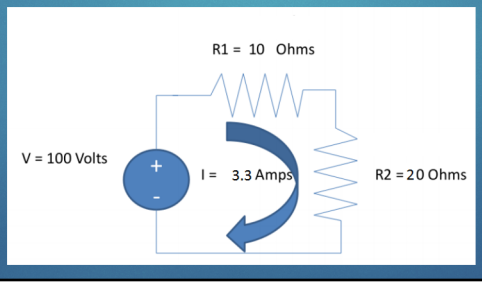
Solve for voltage at R1 and R2.

Total voltage = 100V

Total resistance = 10 + 20 = 30 Ohms

Total current = 100V / 30 Ohms = 3.3 amps

And we know $V_{R1} + V_{R2} = 100V$ (V_{Rx} being the voltage drop)

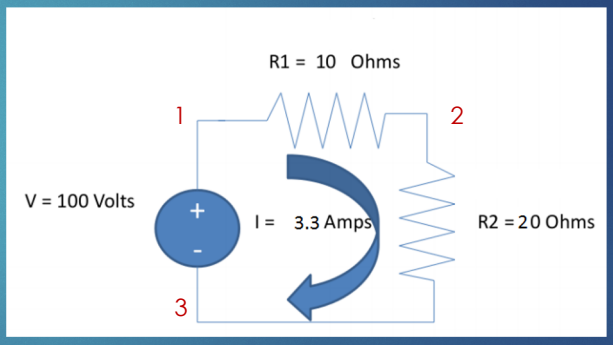


48

Finally Solving…

We can just look at each resistor individually:

- $V_{R1} = I_{R1} * R_{R1}$ (by Ohms Law)
- $V_{R1} = 3.3A * 10\ Ohms \sim= 33V$
  - 33V is the ***drop*** that R1 contributes. So at Point 2, there is (100V – 33V) = ~67V available.
- $V_{R2} = I_{R2} * R_{R2}$ (by Ohms Law)
- $V_{R1} = 3.3A * 20\ Ohms \sim= 67V$
  - This means, at Point 3 there is (67 – 67V) = 0V available!



49

Types of Circuits

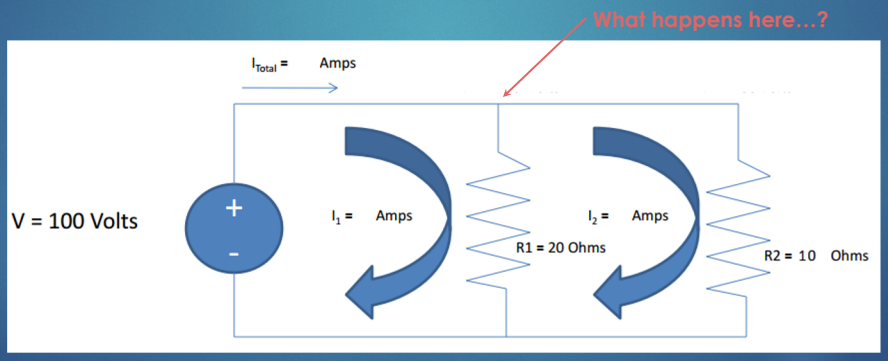
PARALLEL CIRCUITS

50

What is a "parallel" circuit?

Anytime we have multiple paths for electricity to follow (i.e. forks)

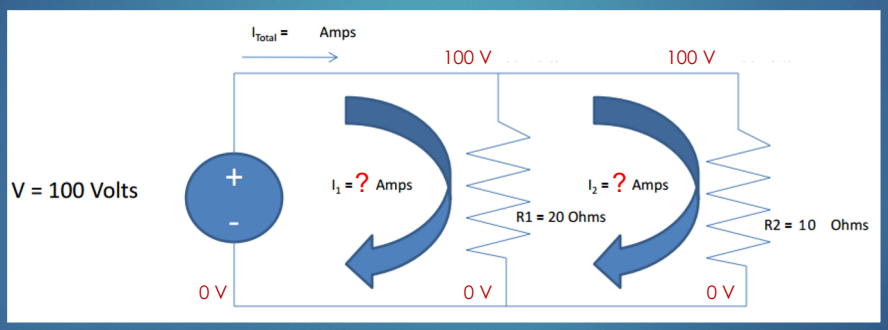
So, we need to know how forks affect our voltage and current…



51

What is a "parallel" circuit?

Characteristic: a fork does not cause voltage to change.



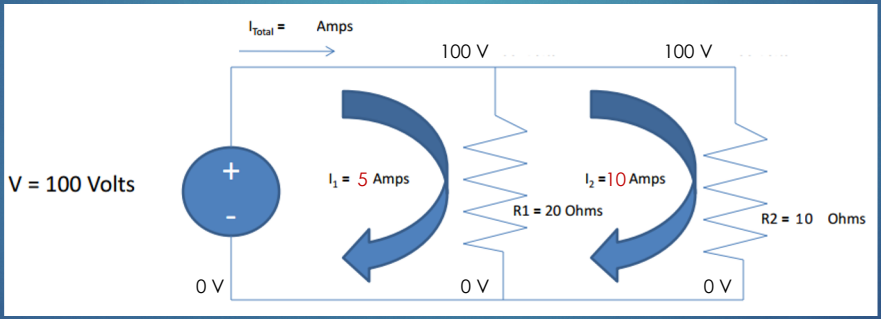
52

Can we apply that?

We now have enough information to calculate the individual currents.

I1 = 100V / 20 Ohms = 5 Amps

I2 = 100V / 10 Ohms = 10 Amps



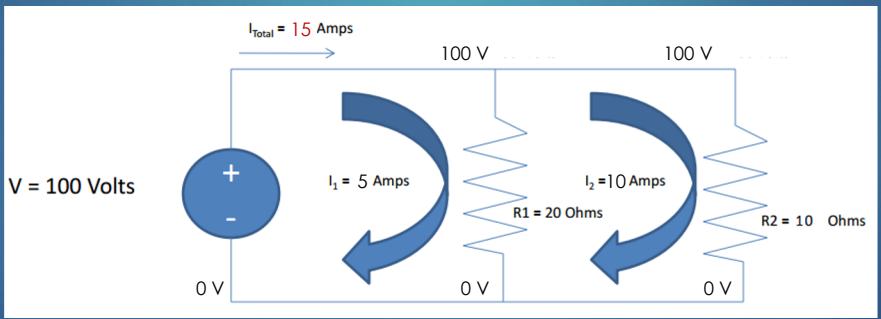
53

Kirchoff's Current Law

To calculate the total current, can we just add the individuals…?

Law: the current flowing into a fork == the total flowing out.

Meaning, $I_{Total} = I_1 + I_2 = 15$ Amps



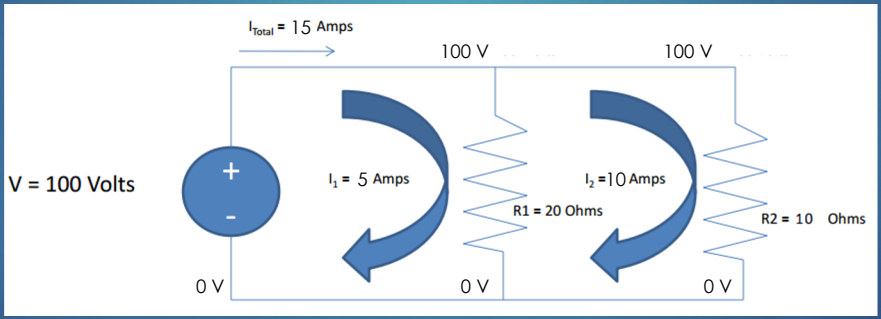
Animation: http://www.mi.mun.ca/users/cchaulk/eltk1100/ivse/ivse.htm#

54

Path of Least Resistance

Current flowing through each branch is proportional to the resistance.

i.e. We saw more current (double) flowing through R_2 than R_1.

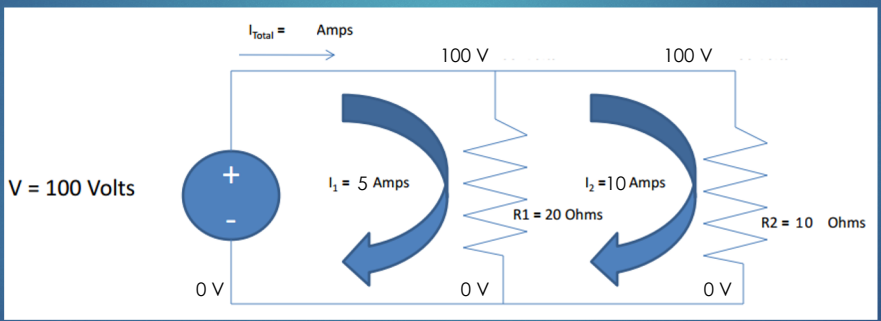


55

Another Way…

We could also calculate I_{Total} if we knew the total resistance (why?)

Can we add the resistors together to get 30 Ohms? Can we currently calculate the total resistance?



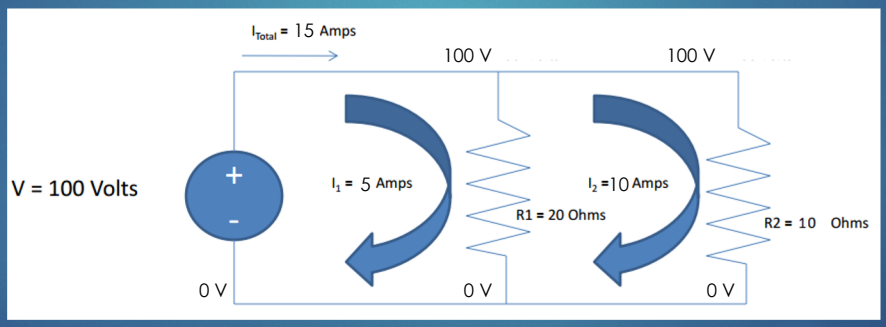
56

Another Way…

R_{total} = 100V / 15 Amps = 6.67 Ohms

In general: R_{total} = 1 / (sum of 1/each resistor) = 1 / (1/20 + 1/10) = 6.67 Ohms

This is only for parallel circuits… what did we do for a series circuit?

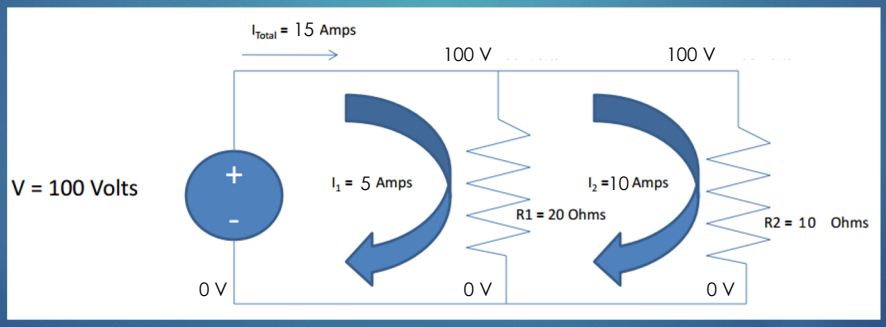


57

Notice…

The total resistance of 6.67 Ohms is actually *less* than any one of the resistors.

Because of the parallel split current, each individual resistor has less overall effect (as opposed to a series circuit).

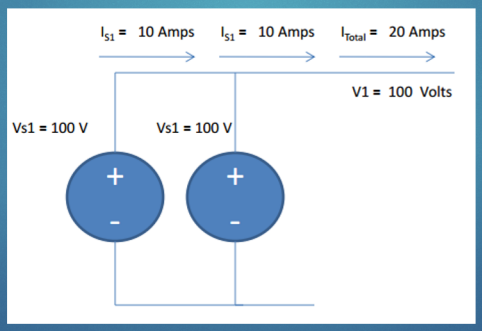


58

Batteries in Parallel?

Batteries in series == voltages get added together

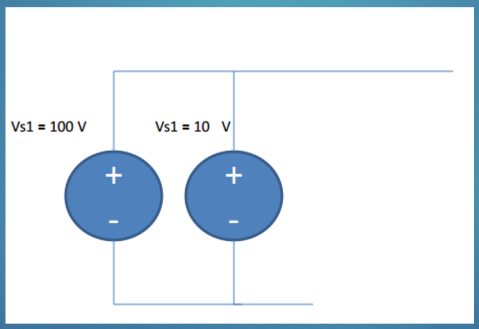
Batteries in parallel == currents gets added together, voltage is the same



59

Batteries in Parallel?

What happens if the batteries are not the same voltages…?



60