

# Introductory Electronics

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<https://goo.gl/vBFPO9>

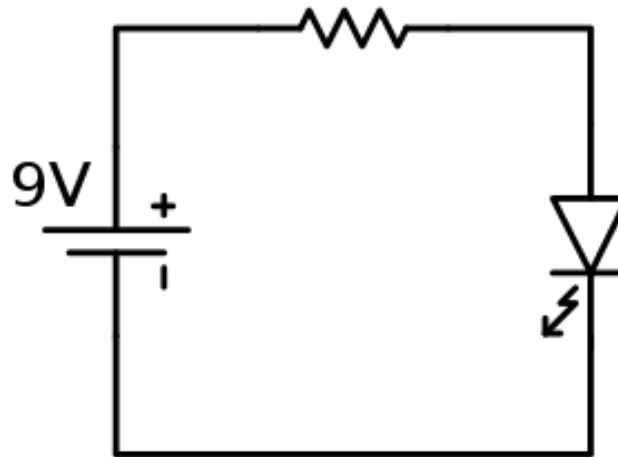
# Overview

- What's an Electrical Circuit?
- Invisible Quantities (V, I, R)
- Safety
- Basic Components
  - Resistors, Batteries, Light Emitting Diodes (LEDs), ICs, Voltage Regulator
- Ohm's & Kirchhoff's Laws
- Simple Circuits
- Integrating to the Parallel Port (basics only)
- Software
- Suppliers
- Textbook & Web References

# What's an Electrical Circuit?

- Every circuit requires these three things:

- Power Source
- Load
- Conductor



- Optionally, a circuit may include a “control device” such as a switch



# Three Main Invisible Quantities

- Voltage, symbol:  $V$ , units: Volts
  - Provides the “push”
- Current, symbol:  $I$ , units: Amperes (Amps)
  - Flow of Electrons
  - Amount of Current is dependent on Voltage and Resistance
- Resistance, symbol:  $R$ , units: Ohms ( $\Omega$ )
  - Limits the amount of current
  - Represents the “load” of the circuit

# Safe Voltage and Current Levels

- Voltage: 30 V
  - Voltages inside a computer do not exceed 12 V,  
*except at the power supply and power switch (on old computers)* **Be careful in these areas!**
- Current: 5 mA (0.005 Amperes)



# Voltage Can Be Provided From...

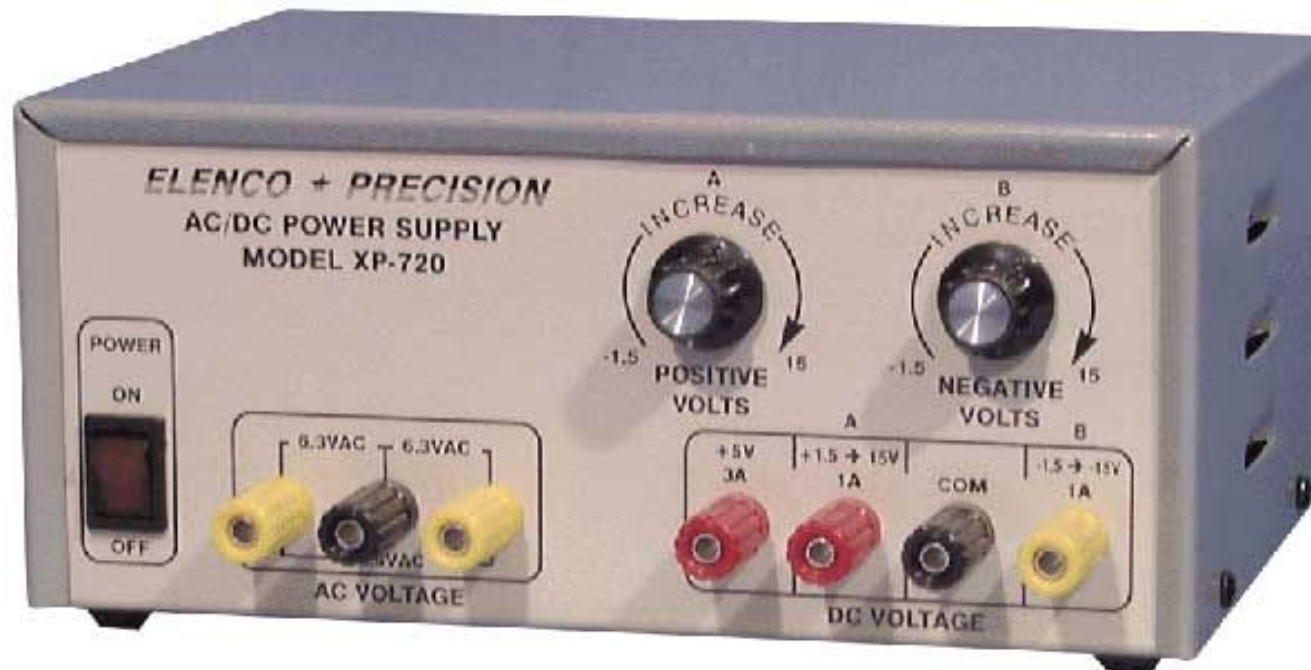
- A battery



*Voltage Can Be Provided From...*

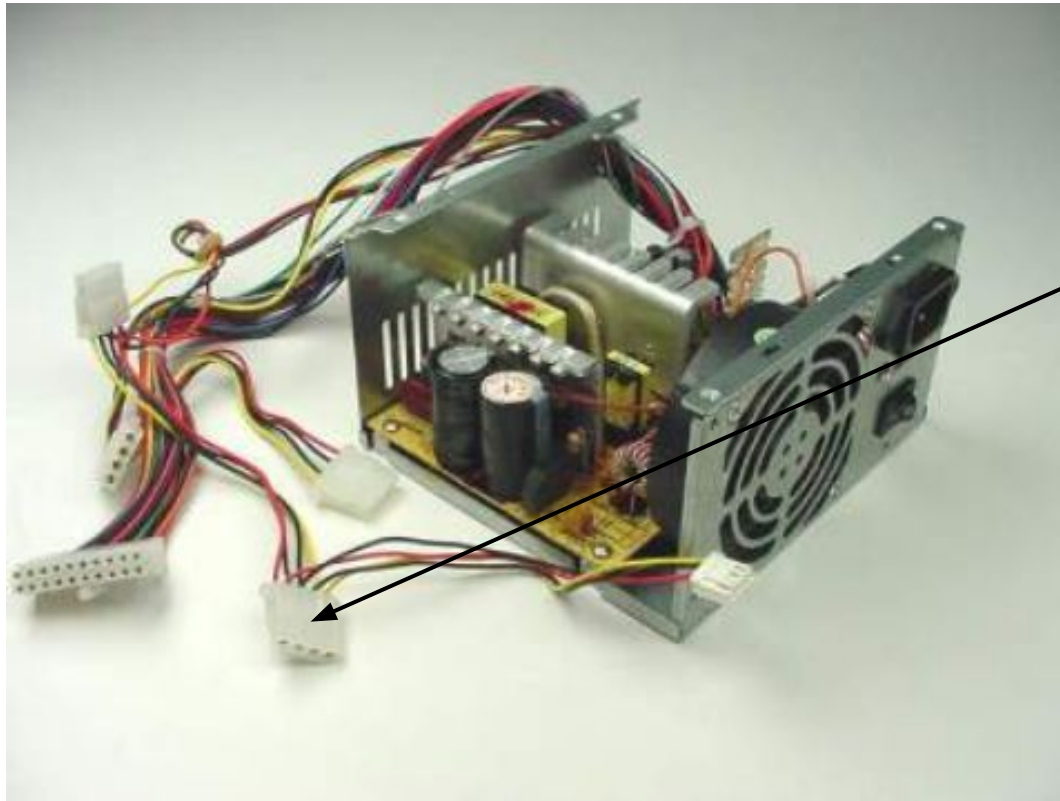
*(cont'd)*

- A conventional power supply



## *Voltage Can Be Provided From... (cont'd)*

- A computer power supply

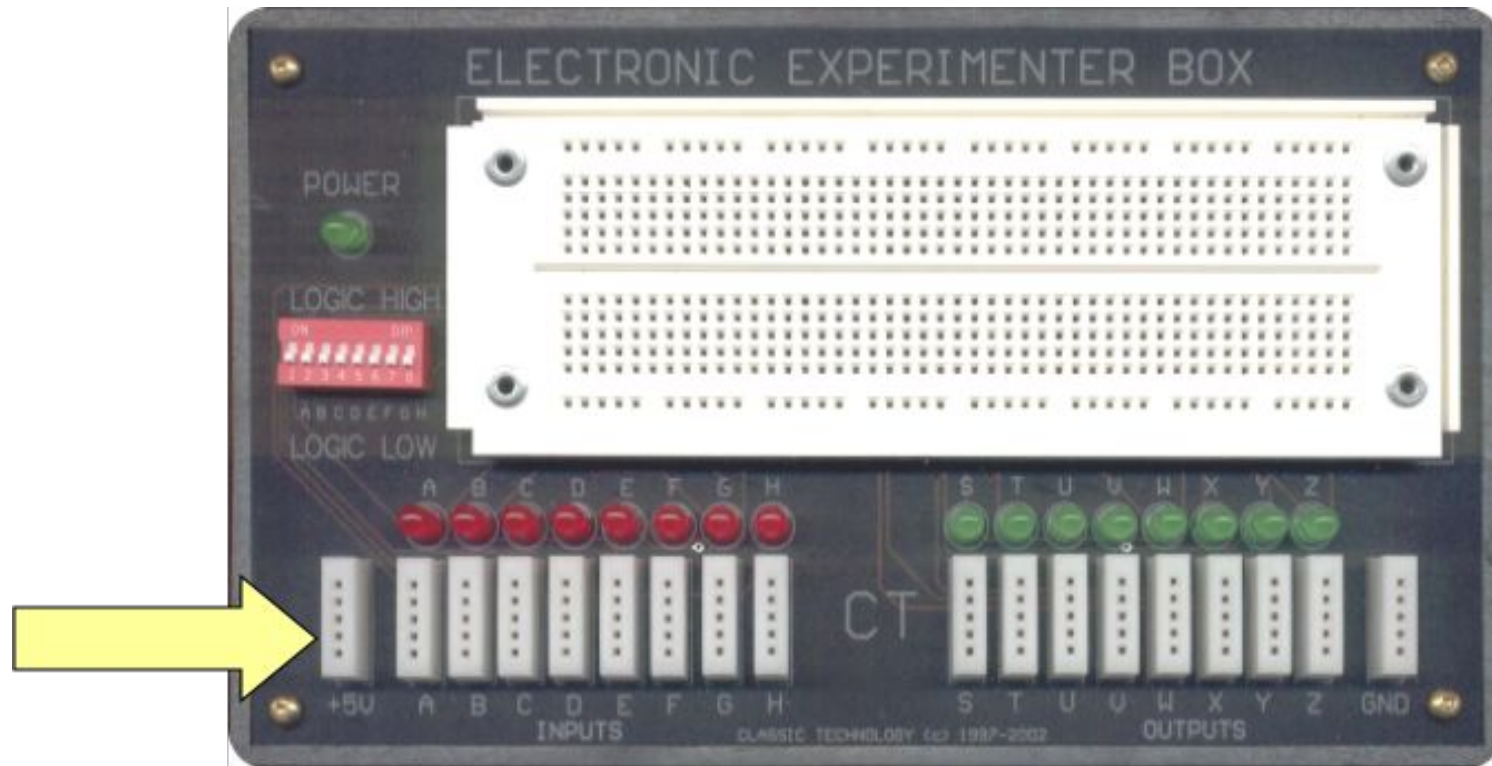


- Red: 5V
- Yellow: 12V
- Black: Ground



## *Voltage Can Be Provided From... (cont'd)*

- A logic trainer



## Voltage Can Be Provided From...

(cont'd)

- The computer parallel port (aka printer port)

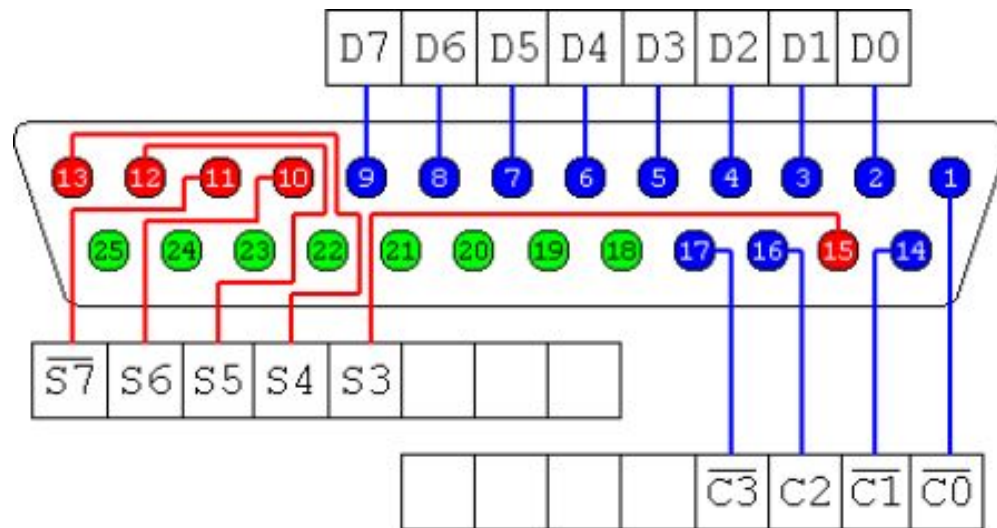
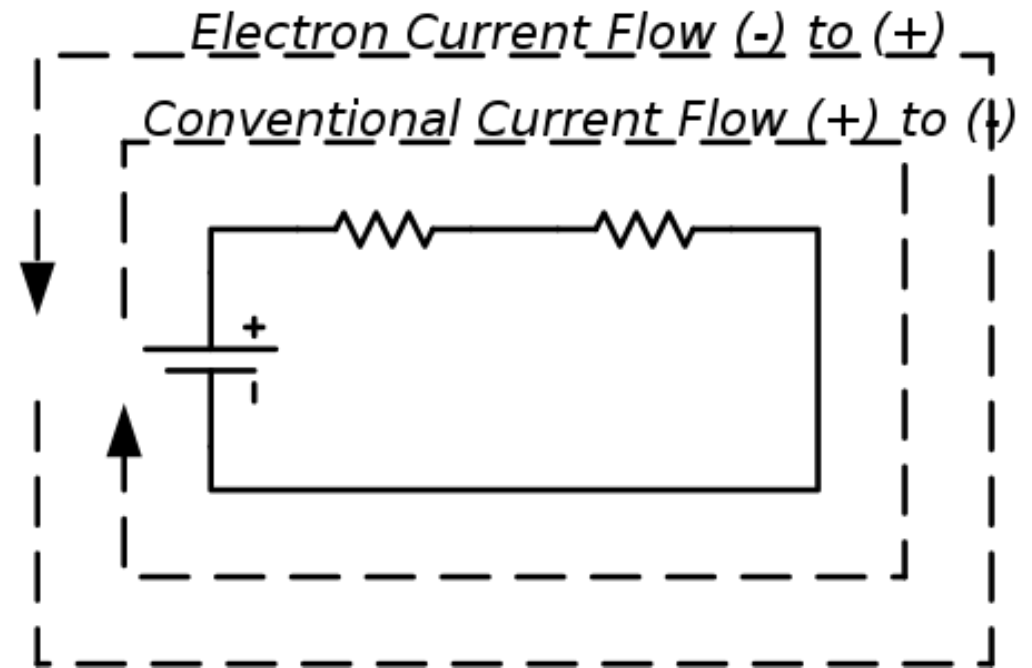


Diagram from

<http://www.doc.ic.ac.uk/~ih/doc/par/>

# Current

- ...is simply the flow of electrons
  - The “direction” depends on convention
- 
- Electron flow is from - to + (*flow of electrons*)
  - Conventional flow is from + to - (*hole flow*)



# Resistors – Basic Specs

- Can be rated by...
  - Resistance (Ohms,  $\square$ )
  - Tolerance (% of nominal value)
  - Power Rating (Watts)
- Schematic Symbol...

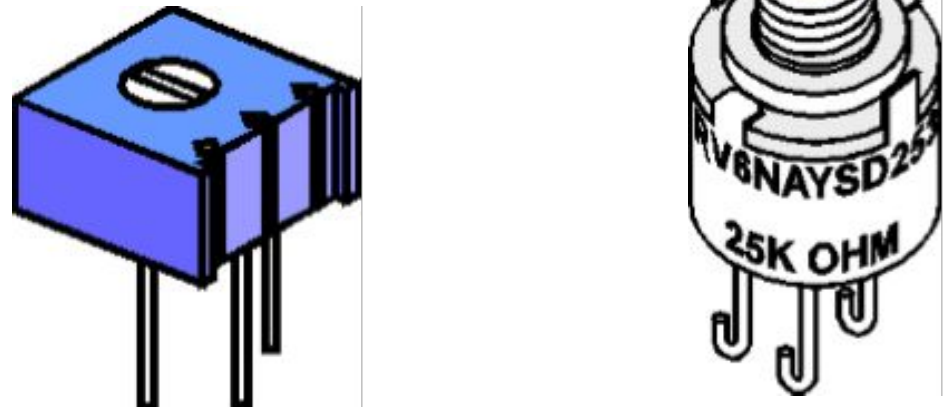


# Resistors – Types

- Fixed

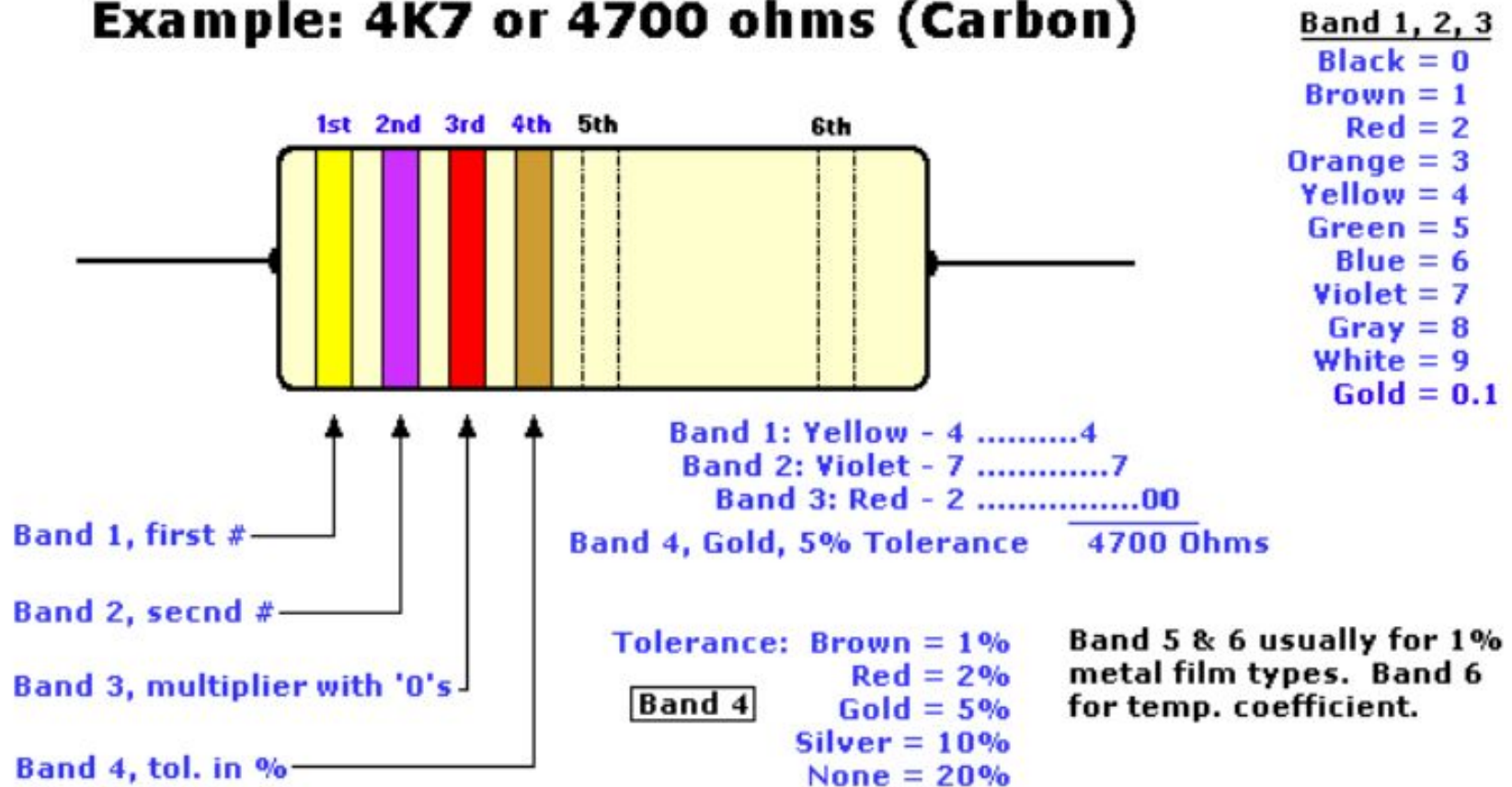


- Variable (Potentiometer, Rheostat)



# Resistors – Colour Code

**Example: 4K7 or 4700 ohms (Carbon)**



# Resistors – Colour Code

**Calculate Resistor Values from Color Codes**

Black Black Black Gold

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Resistance Value: 0 ohms, +/-5%




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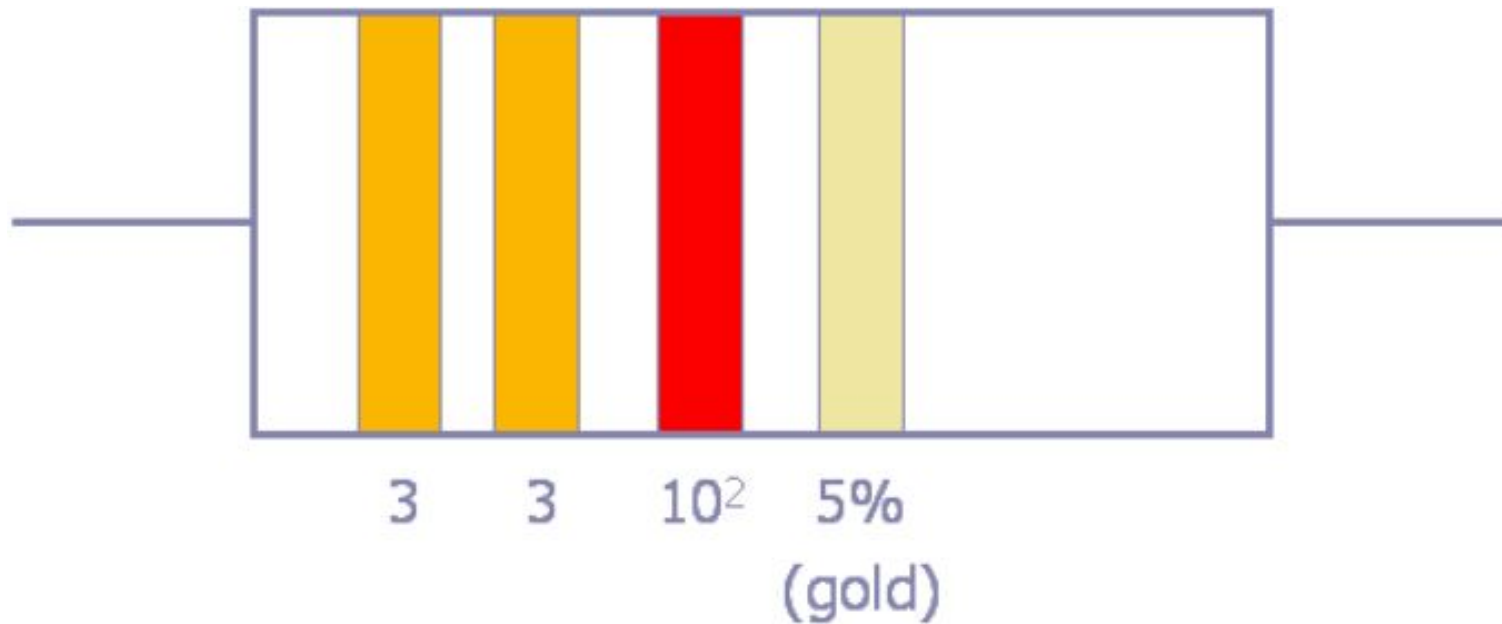
GRAPHICAL RESISTANCE CALCULATOR in JAVASCRIPT  
Version 2.2  
by Danny Goodman, AE9F ([www.dannyg.com](http://www.dannyg.com))  
Analyzed and described at length in  
"JavaScript Bible"

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This program is Copyright 1996, 2001 by Danny Goodman. You may adapt this calculator for your Web pages, provided these opening credit lines (down to the lower dividing line) are in your outliner HTML document. You may not reprint or redistribute this code without permission from the author.

Javascript Resistance Calculator available at  
<http://www.beens.org/misc/resCalc/resistor.ht>

# Resistors – Colour Code Example



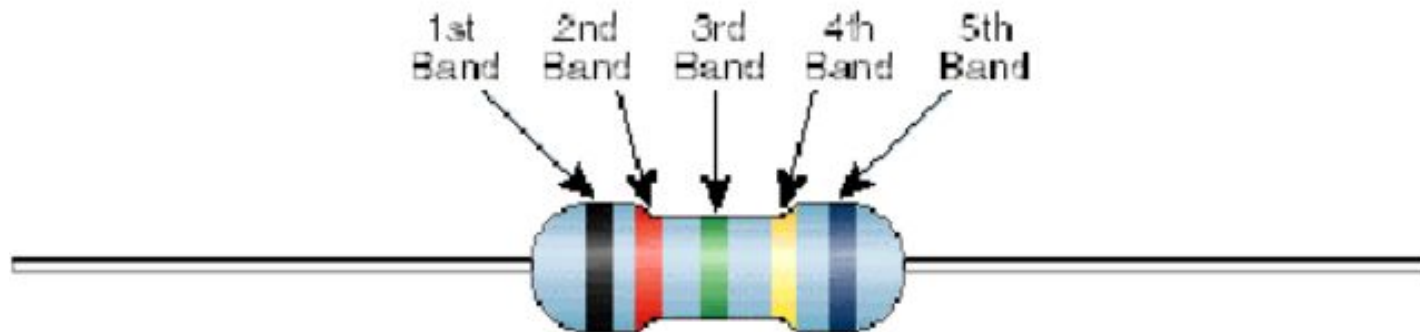
- 1<sup>st</sup> band: orange = 3
- 2<sup>nd</sup> band: orange = 3
- 3<sup>rd</sup> band: red = 2 (i.e. 10<sup>2</sup>)
- 4<sup>th</sup> band: gold = 5%

$$\begin{aligned} & 33 \times 10^2 \\ & = 3300 \, \Omega \\ & = 3.3 \, \text{k}\Omega \end{aligned}$$



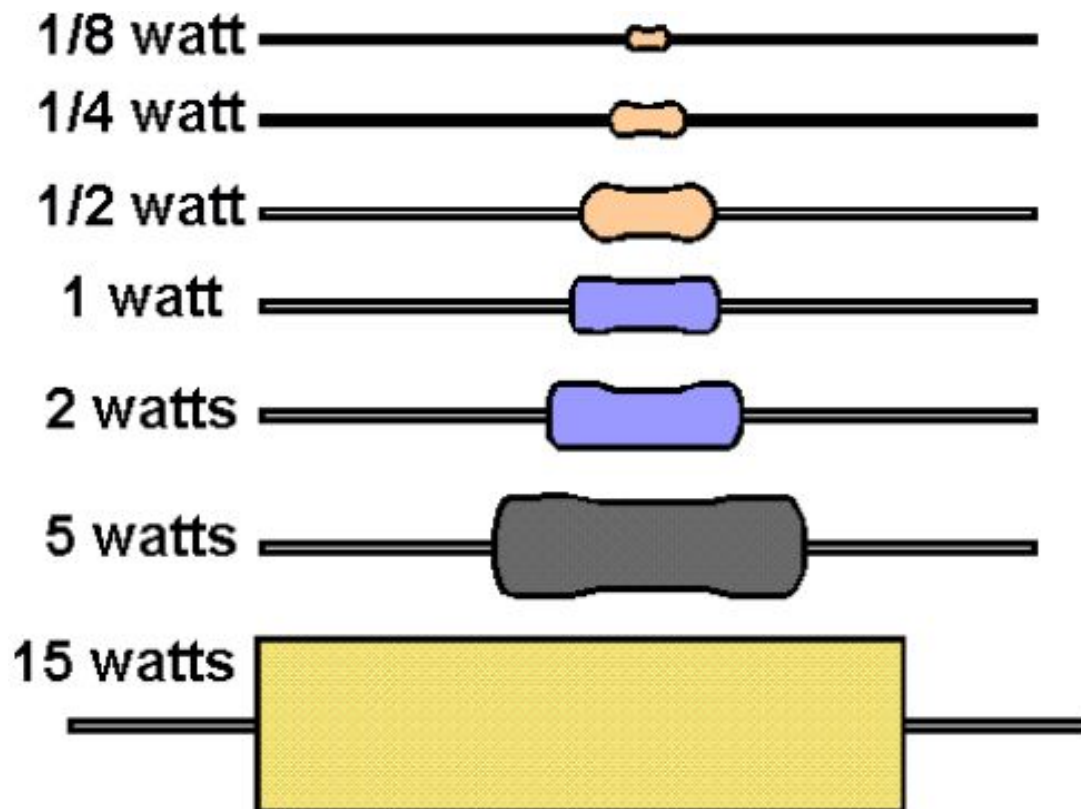
# Resistors – 5 Band Colour Code

**Standard EIA Color Code Table 5 Band:  $\pm 1\%$ ,  $\pm 0.25\%$ ,  $\pm 0.5\%$ ,  $\pm 1\%$**



Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (3rd figure)	4th Band (multiplier)	5th Band (tolerance)
Black	0	0	0	$10^0$	
Brown	1	1	1	$10^1$	$\pm 1\%$
Red	2	2	2	$10^2$	
Orange	3	3	3	$10^3$	
Yellow	4	4	4	$10^4$	
Green	5	5	5	$10^5$	$\pm 0.5\%$
Blue	6	6	6	$10^6$	$\pm 0.25\%$
Violet	7	7	7	$10^7$	$\pm 0.1\%$
Gray	8	8	8	$10^8$	
White	9	9	9	$10^9$	
Gold				$10^{-1}$	

# Resistors – Typical Power Ratings

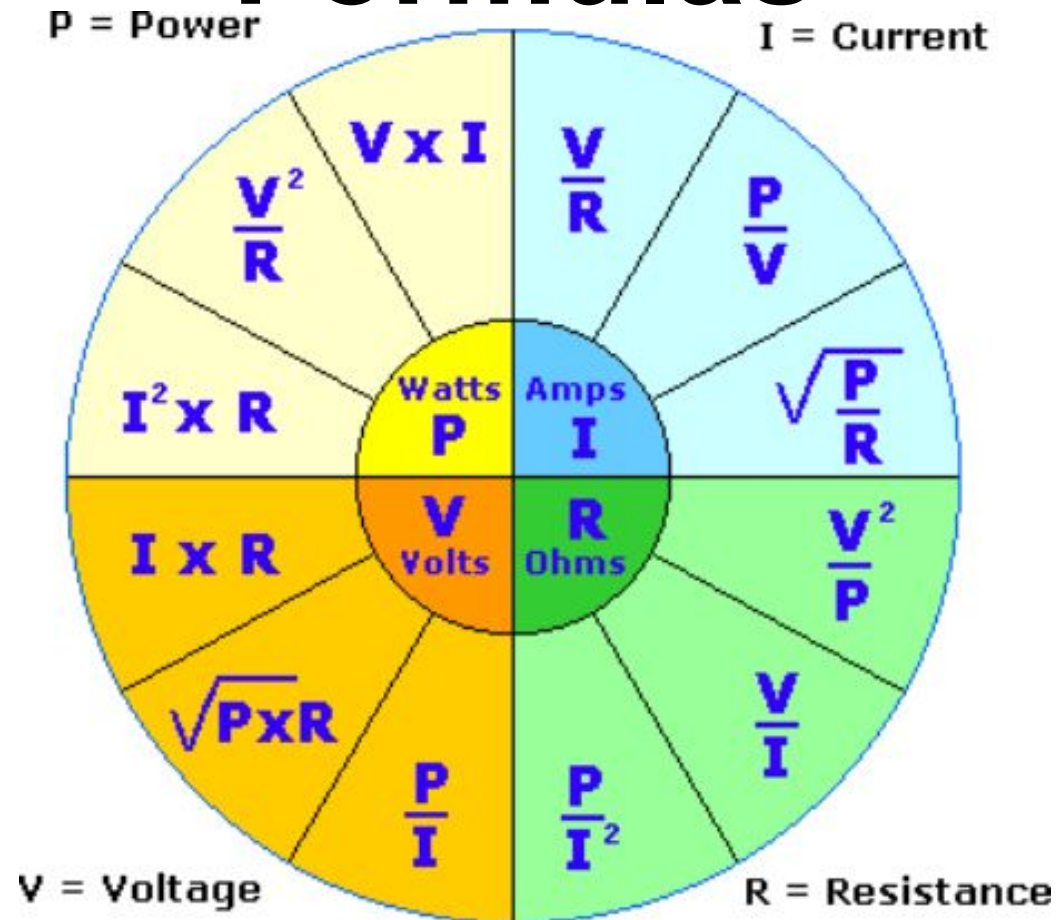


# Ohm's Law

“Current (I) is proportional to Voltage (V) and inversely proportional to Resistance (R)”

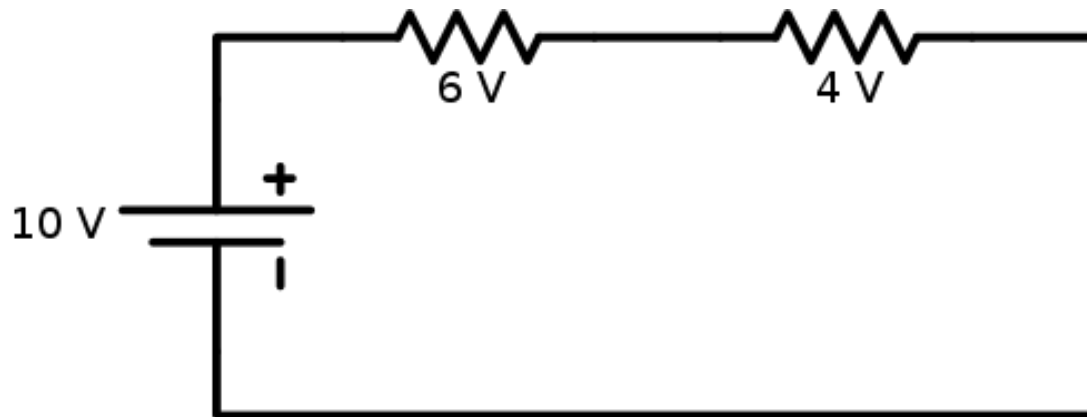
$$I = V / R \quad V = I \times R \quad R = V / I$$

# Ohm's Law and Power Formulas



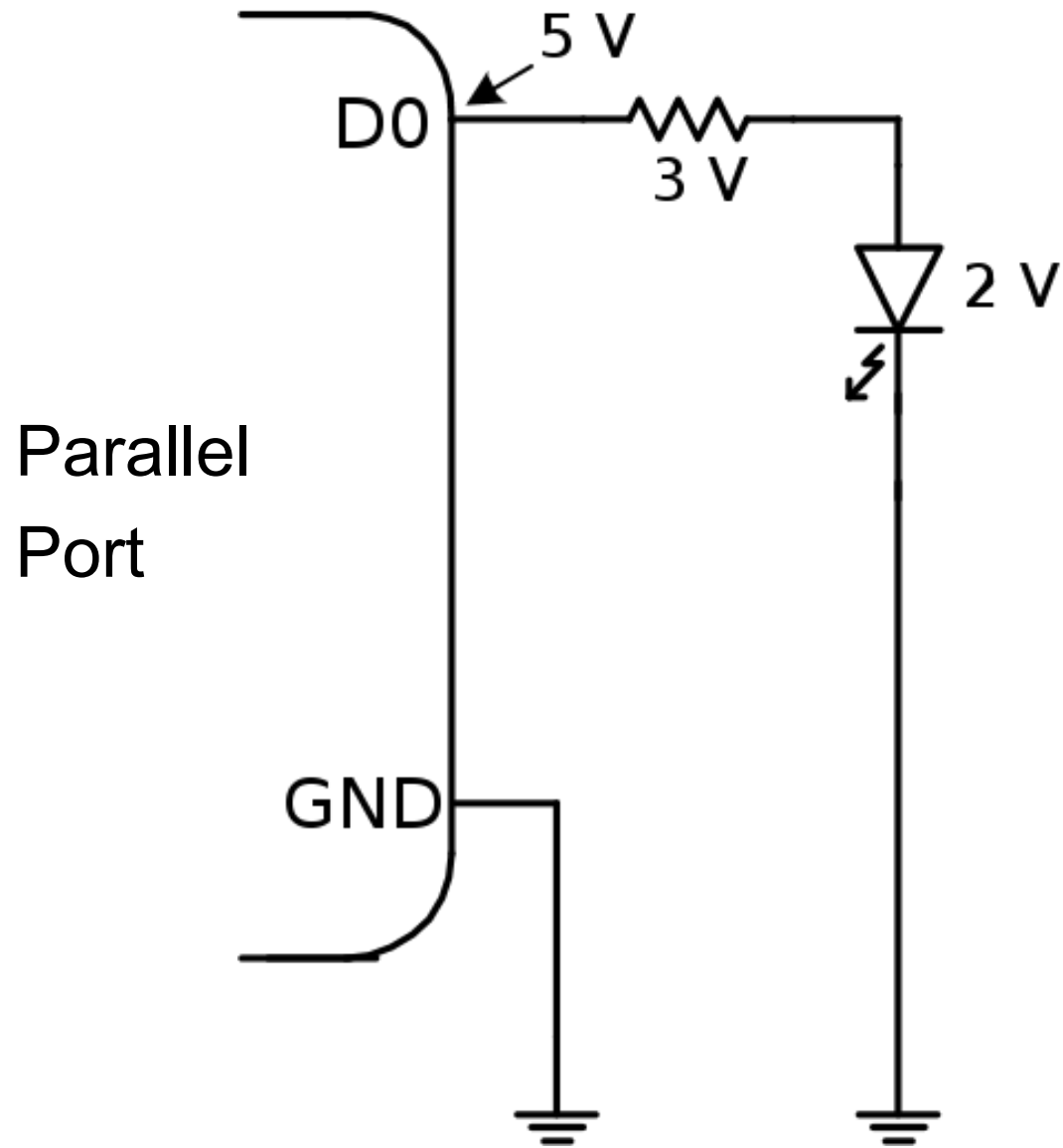
# Kirchhoff's Voltage Law

- Used in series circuits (such as LED circuit)
- “The sum of the voltage drops equals the applied voltage”, or...
- “The sum of the voltage drops around a closed loop equals zero”



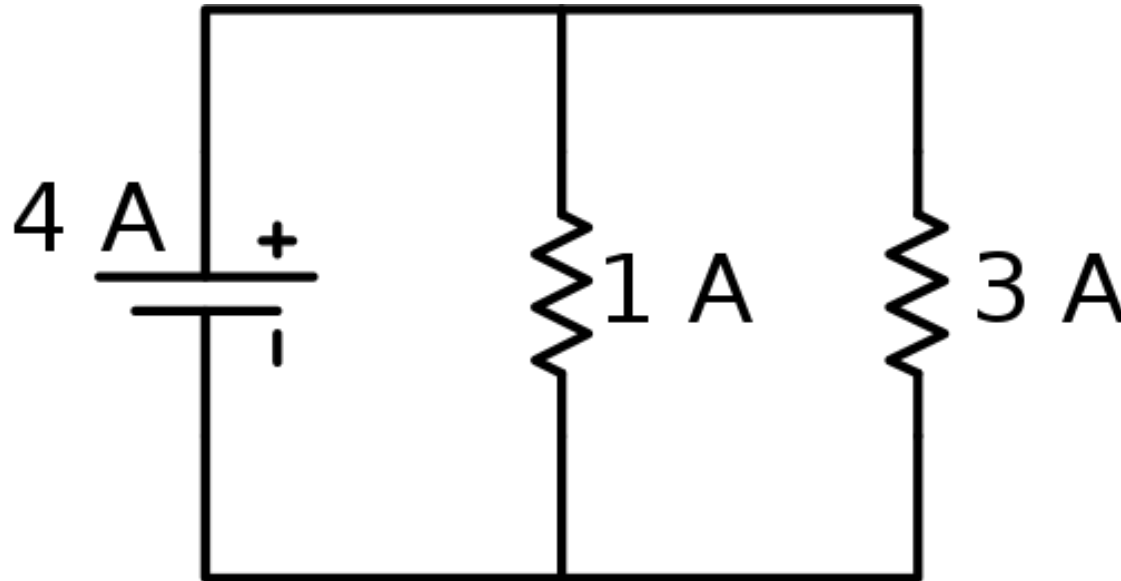
# Kirchhoff's Voltage Law

(cont'd)



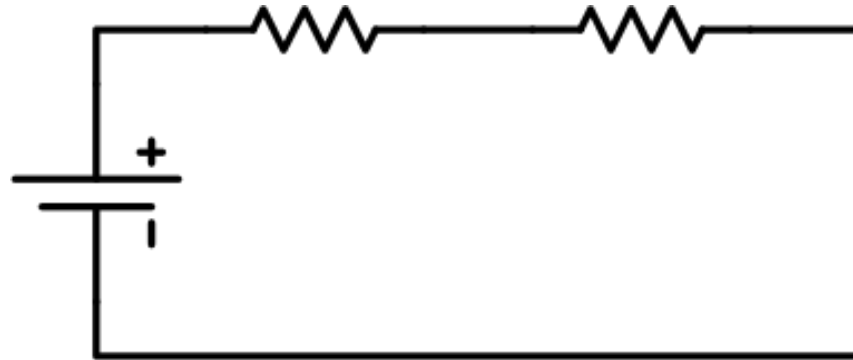
# Kirchhoff's Current Law

- Use in parallel circuits.
- “The current entering a junction must equal the current leaving the junction”



# Series Circuits

- One current path, therefore the current is the same everywhere



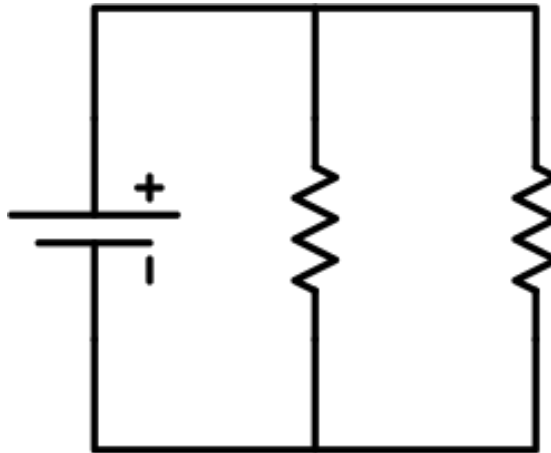
- Total resistance is the sum of the individual resistances

$$R_T = R_1 + R_2 + \dots$$



# Parallel Circuits

- More than one current path



- Total current is the sum of the individual currents

$$I_T = I_1 + I_2 + \dots$$

## ***Parallel Circuits (cont'd)***

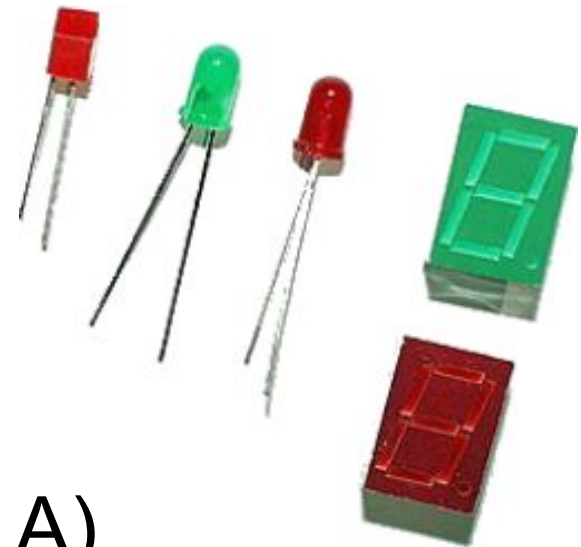
$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots}$$

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2} \text{ (if 2 only)}$$

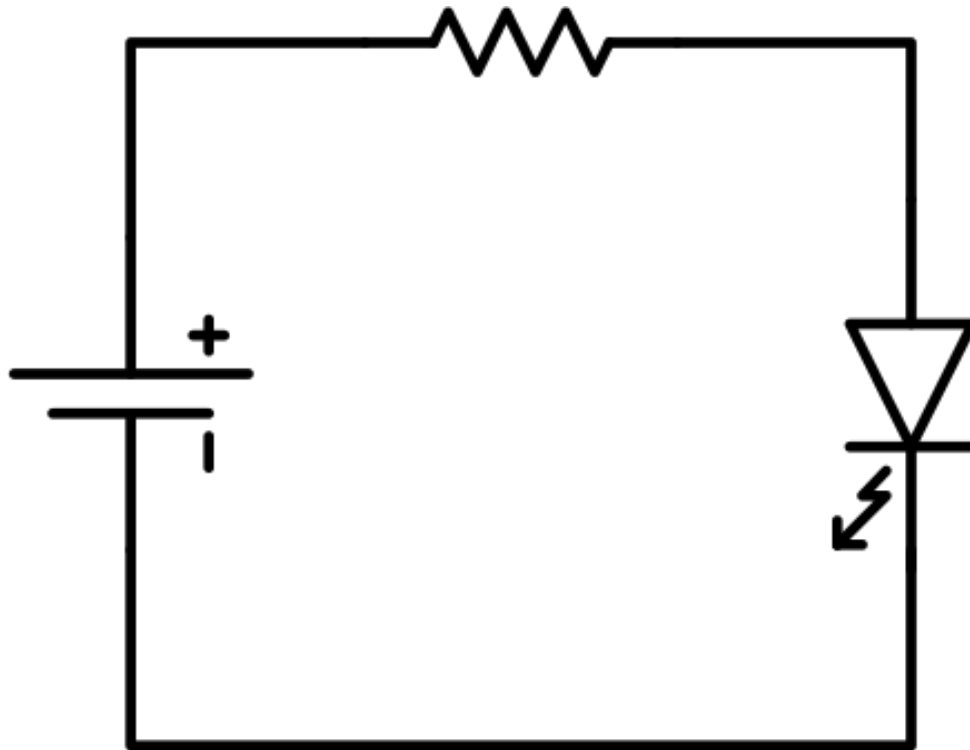
$$R_T = \frac{R}{n} \text{ (if the same value)}$$

# Light Emitting Diodes

- A type of diode designed to emit light
- Can be visible or IR
- 2 V voltage drop
- Typically draws 20 mA (0.020 A)
- Schematic Symbol...



# A Simple LED Circuit



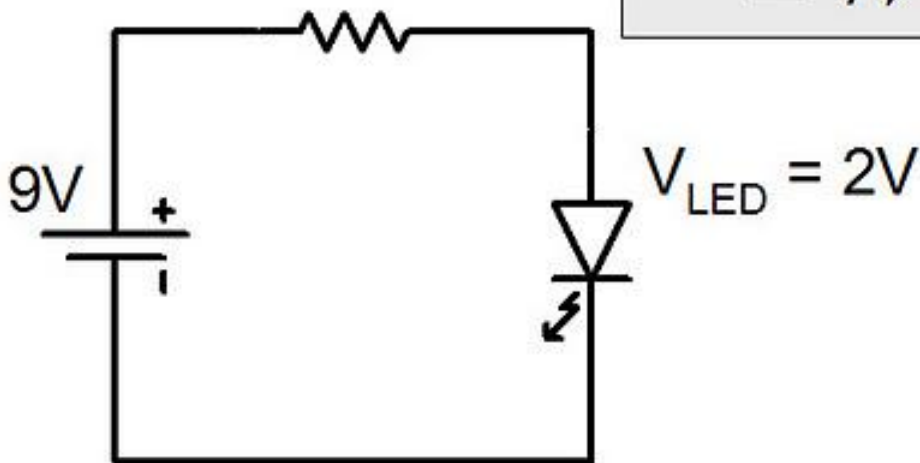
# Analyzing a LED Circuit with KVL and Ohm's Law

$$V_T = V_R + V_{LED}$$

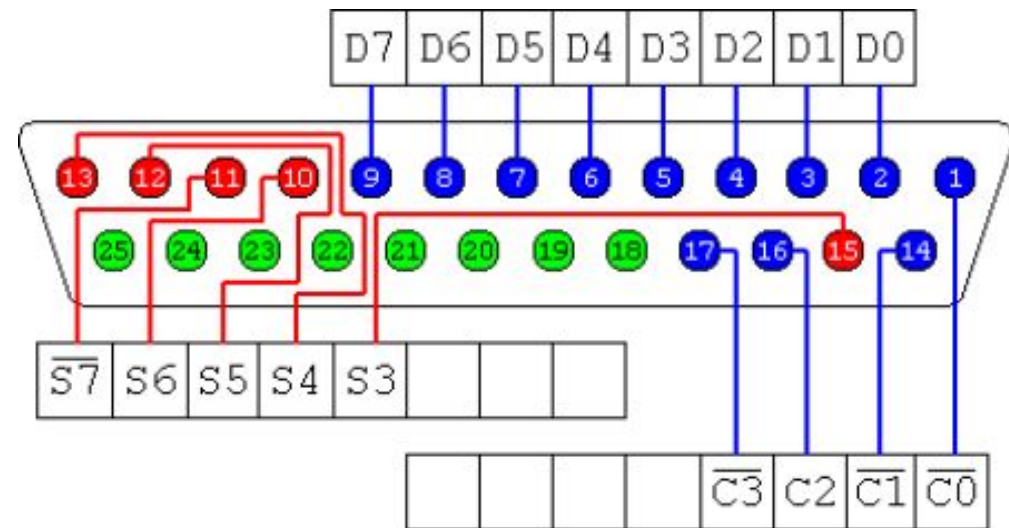
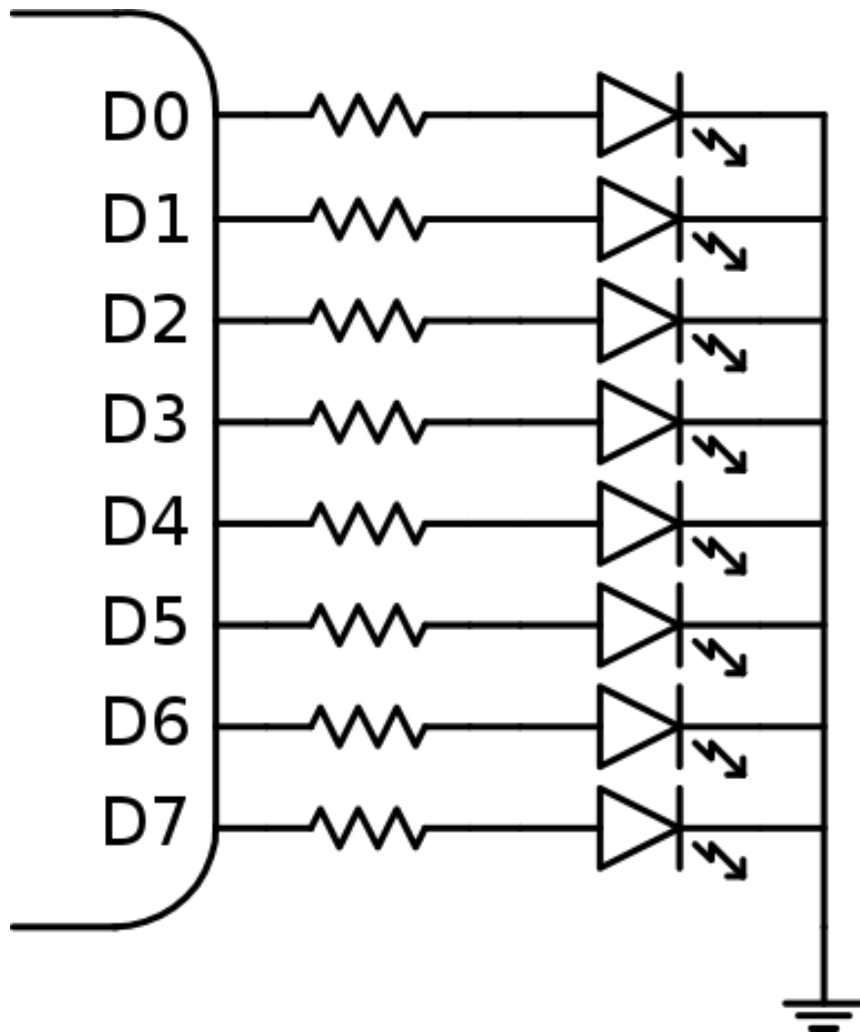
$$I_{LED} = I_R = 20 \text{ mA}$$

$$\begin{aligned} V_R &= V_T - V_{LED} \\ &= 9 - 2 \\ &= 7 \text{ V} \end{aligned}$$

$$\begin{aligned} R &= \frac{V_R}{I_R} \\ &= \frac{7 \text{ V}}{0.020 \text{ A}} \\ &= 350 \ \Omega \end{aligned}$$

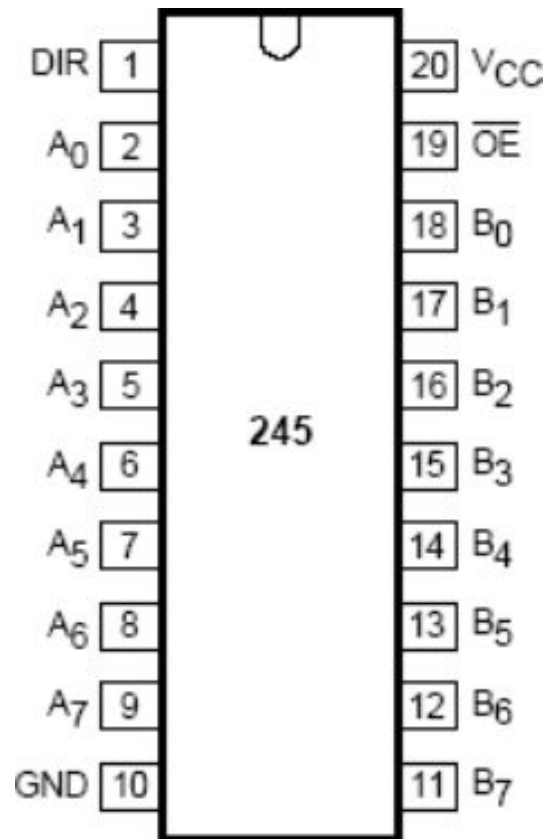


# Interfacing LEDs to the Parallel Port

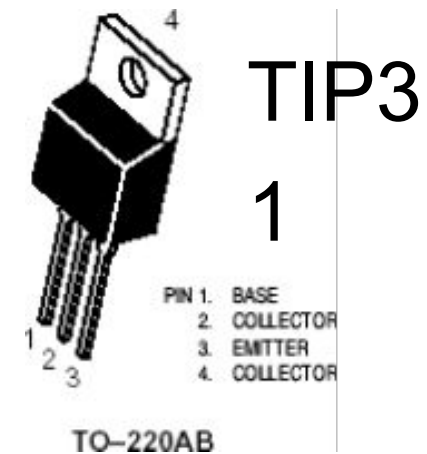
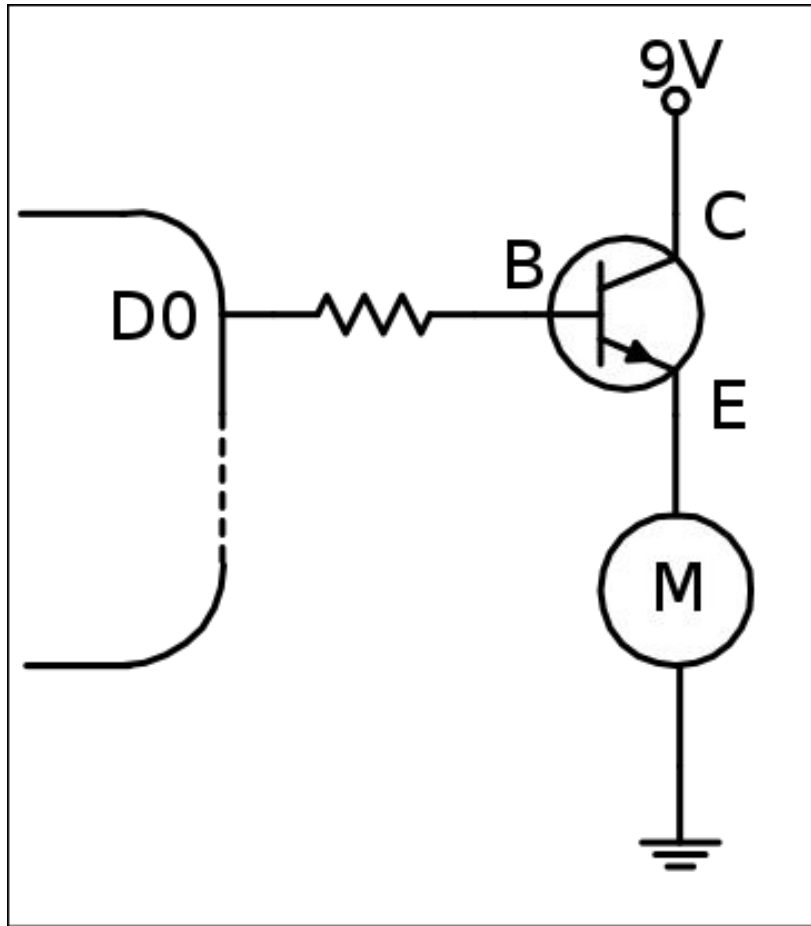


# Protecting the Parallel Port

- Use a 74LS245 “Octal Bus Transceiver” to protect the computer parallel port



# Interfacing a Motor to the Parallel Port

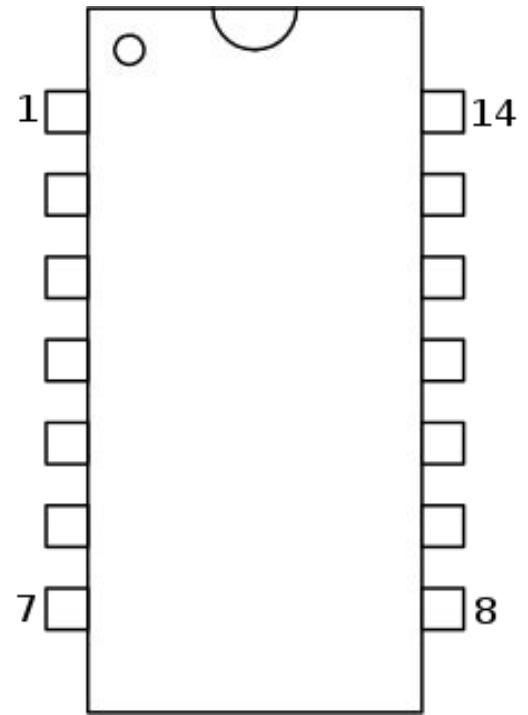


(A stepper motor would require more outputs)



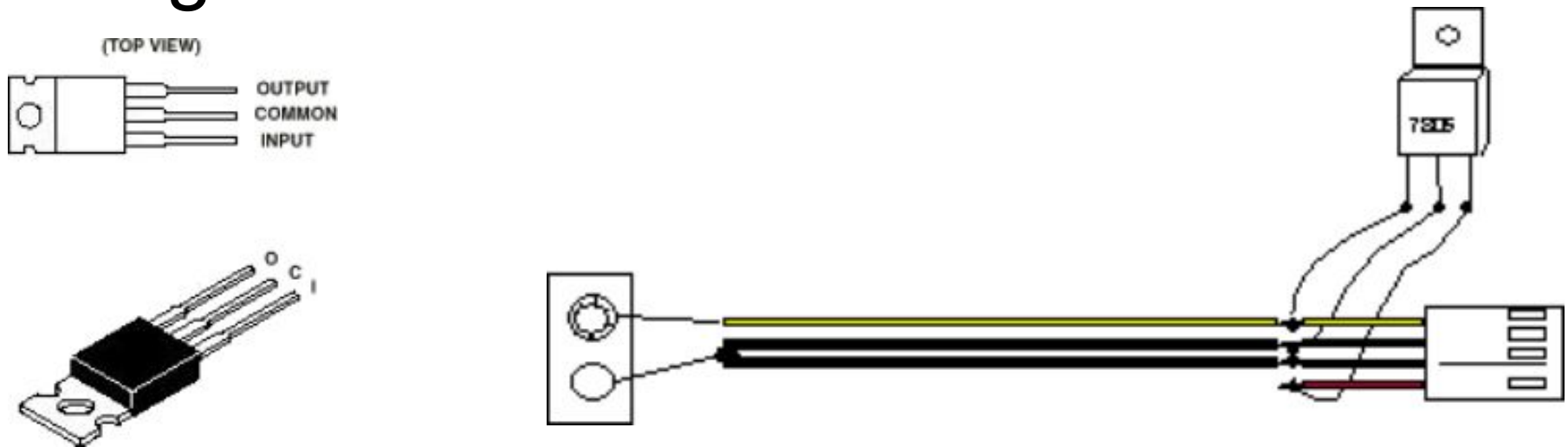
# Integrated Circuits

- 7400 series typically used for logic gate experiments (AND, OR, etc.)
- Very susceptible to voltage variations and static discharge
- Note pin 1 on diagram
- Refer to applicable data-sheet for pinouts



# 7805 Voltage Regulator

- Part of the 78xx series of voltage regulators
- Can be used to convert 9 V to 5 V for digital circuits



*Reproduced with permission; see  
<http://ohmslaw.com/Steps.htm>*

# Electronics Software - ETCAI

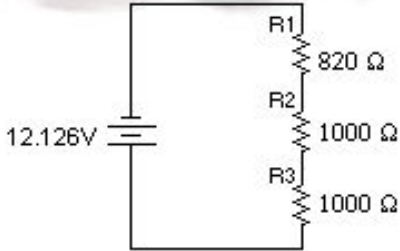
\$229 US per module.

Modules: Basic Circuits,  
DC Circuits, Ohmmeter,  
AC Circuits, Solid State,  
Op Amps, Power  
Supplies, Digital

Available from

[www.etcai.com/](http://www.etcai.com/)

**SERIES CIRCUIT ONE** Resistor values and voltage source known



Type your answers in the spaces provided. Use the **C** buttons to check answers. No points are deducted for right answers. Two points are deducted for wrong answers. Use the **Grade** button to have all your answers graded. You will have the option to print a certificate after your answers are graded.

The **HELP** option gives formulas and hints for solving the problem. Keep in mind that there are often one or more sequences that must be followed in order to solve a problem. Choosing the **HELP** options in the wrong sequence may be of little value. Some problems have several correct methods and sequences for finding solutions. The **HELP** information presented is merely one of perhaps several ways to solve the problem.

**Series One**

RT	2820	Ω	<b>C</b>	8 pts
IT		mA	<b>C</b>	8 pts
IR1		mA	<b>C</b>	8 pts
IR2		mA	<b>C</b>	8 pts
IR3		mA	<b>C</b>	8 pts
VR1		V	<b>C</b>	8 pts
VR2		V	<b>C</b>	8 pts
VR3		V	<b>C</b>	8 pts
PT		mW	<b>C</b>	8 pts
PR1		mW	<b>C</b>	8 pts
PR2		mW	<b>C</b>	8 pts
PR3		mW	<b>C</b>	8 pts

Maximum possible score = 100

**Grade**

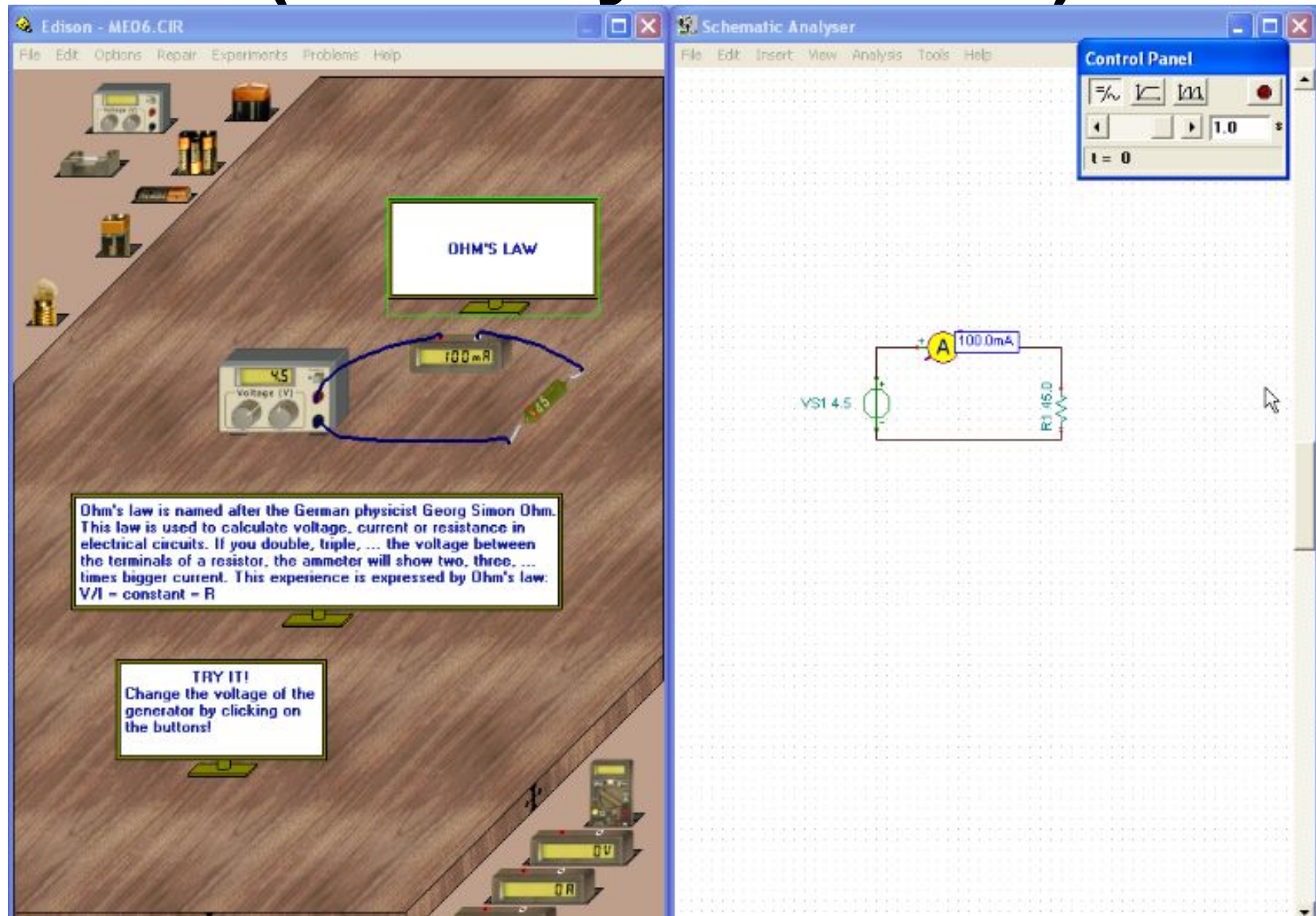
**Help**

**Quit**

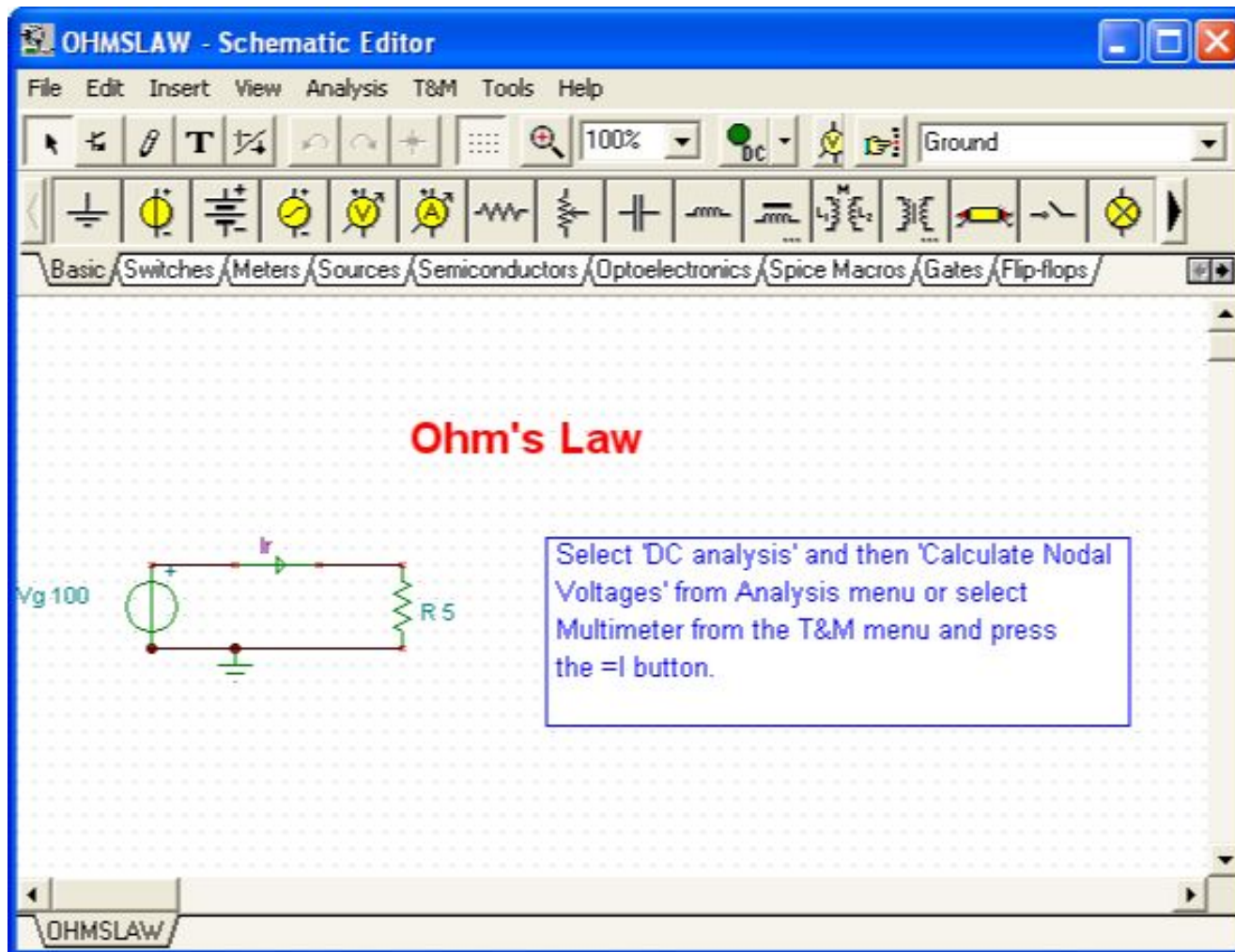
Fri, 17-Nov-2006 16:42:27

Time on task: 00:00:11

# Electronics Software – Edison (Ministry-licensed)



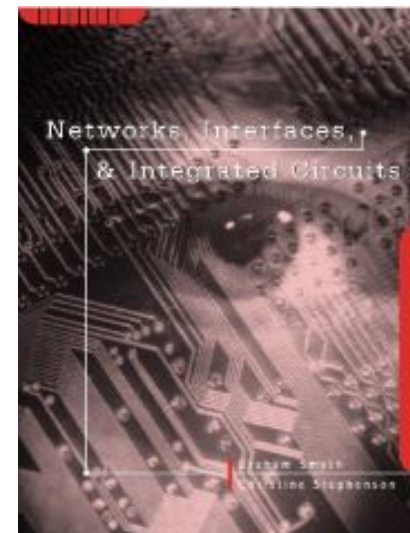
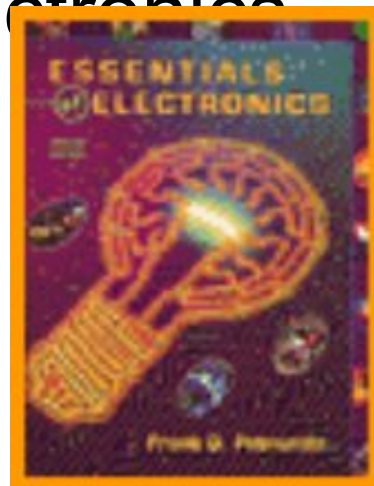
# Electronics Software – Tina (Ministry-licensed)





# Textbook References

- Computer Engineering:  
An Activity-Based  
Approach (Holt)
- Networks, Interfaces  
and Integrated Circuits (Holt)
- Essentials of Electronics  
(Petruszella)



# Suppliers

- Abra Electronics

- <http://www.abra-electronics.com/>
- (800) 361-5237

- Digi-Key

- <http://dkc1.digikey.com/ca/digihome.html>
- (800) 344-4539

# Web References

- All About Circuits
  - <http://www.allaboutcircuits.com/>
- Electronics Tutorials
  - <http://www.electronics-tutorials.com/>
- Jones on Stepper Motors
  - <http://www.cs.uiowa.edu/~jones/step/>
- Tony's Website (Tony van Roon)
  - <http://www.sentex.ca/~mec1995/>
    - Many excellent tutorials, example circuits
- Electronics Wiki (Wikipedia)
  - <http://en.wikipedia.org/wiki/Electronics>



# Credits

- Parallel Pinout Diagram
  - Ian Harries <[ih@doc.ic.ac.uk](mailto:ih@doc.ic.ac.uk)>
  - <http://www.doc.ic.ac.uk/~ih/doc/par/>
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- Trainer Picture
  - [classic@classictech.on.ca](mailto:classic@classictech.on.ca) (London, ON)
  - <http://www.classictech.on.ca/>
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  - Quality RF Services, Inc.
  - <http://www.qrf.com/>

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- Ohm's Law & Colour Code Pictures

- <http://www.uoguelph.ca/~antoon/>

- Used with permission

- 7805 with 9V Battery Diagram

- "Floppy the Robot"

- <http://ohmslaw.com/Steps.htm>

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# Contact Info...

- Peter Beens
- Web: <http://www2.beens.org>
- Email: [pbeens@gmail.com](mailto:pbeens@gmail.com)

# Final Thoughts...

$$2 = 1$$

---

Start with. . . . .  $a = b$   
multiply both sides by  $a$  . . . . .  $aa = ab$   
reducing  $aa$  to  $a^2$  . . . . .  $a^2 = ab$   
subtract  $b^2$  from both sides . . . . .  $a^2 - b^2 = ab - b^2$   
factoring, we get . . . . .  $(a - b)(a + b) = b(a - b)$   
divide both sides by  $(a - b)$  . . . . .  $a + b = b$   
remember that  $a = b$  . . . . .  $b + b = b$   
reduces to . . . . .  $2b = b$   
divide both sides by  $b$  . . . . .  $2 = 1$