Introductory Electronics

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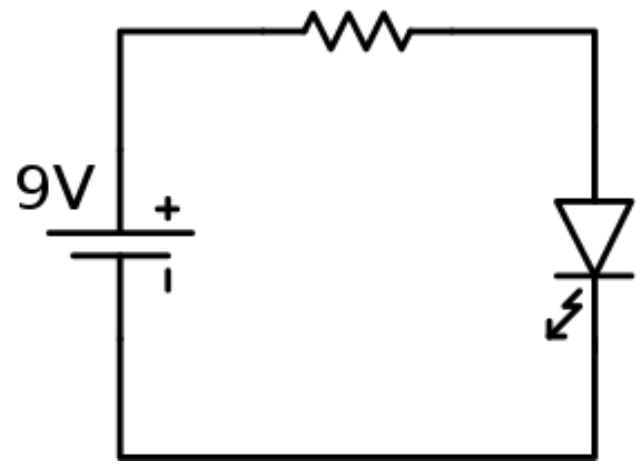
https://goo.gl/vBFPO9

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 (Ω)
  - 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!**

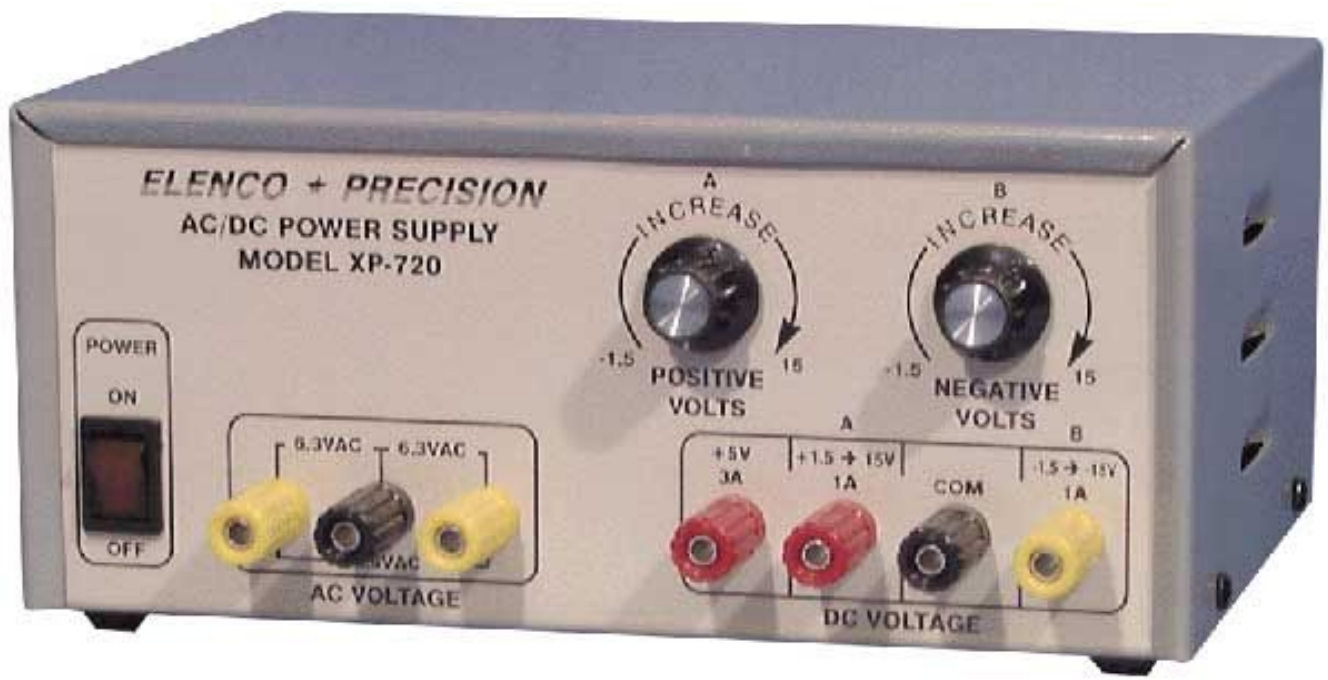
- Current: 5 mA (0.005 Amperes)

Voltage Can Be Provided From…

- A battery

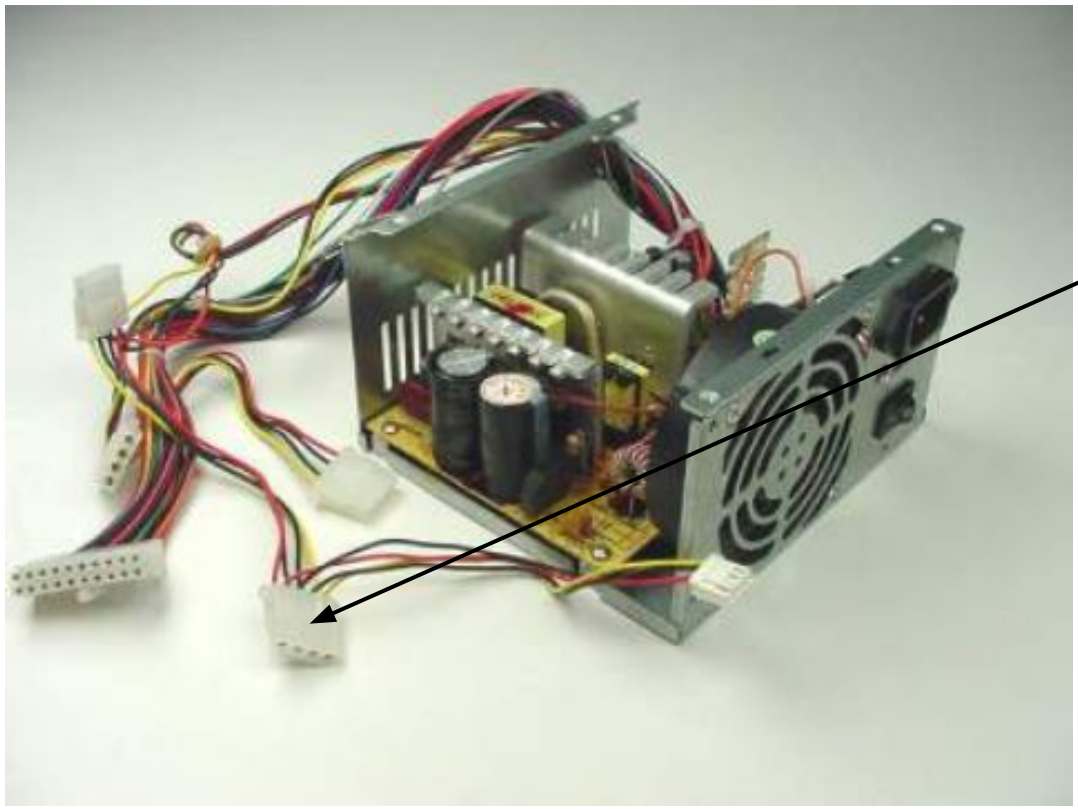
Voltage Can Be Provided From…
(cont'd)

- A conventional power supply



Voltage Can Be Provided From… (cont'd)

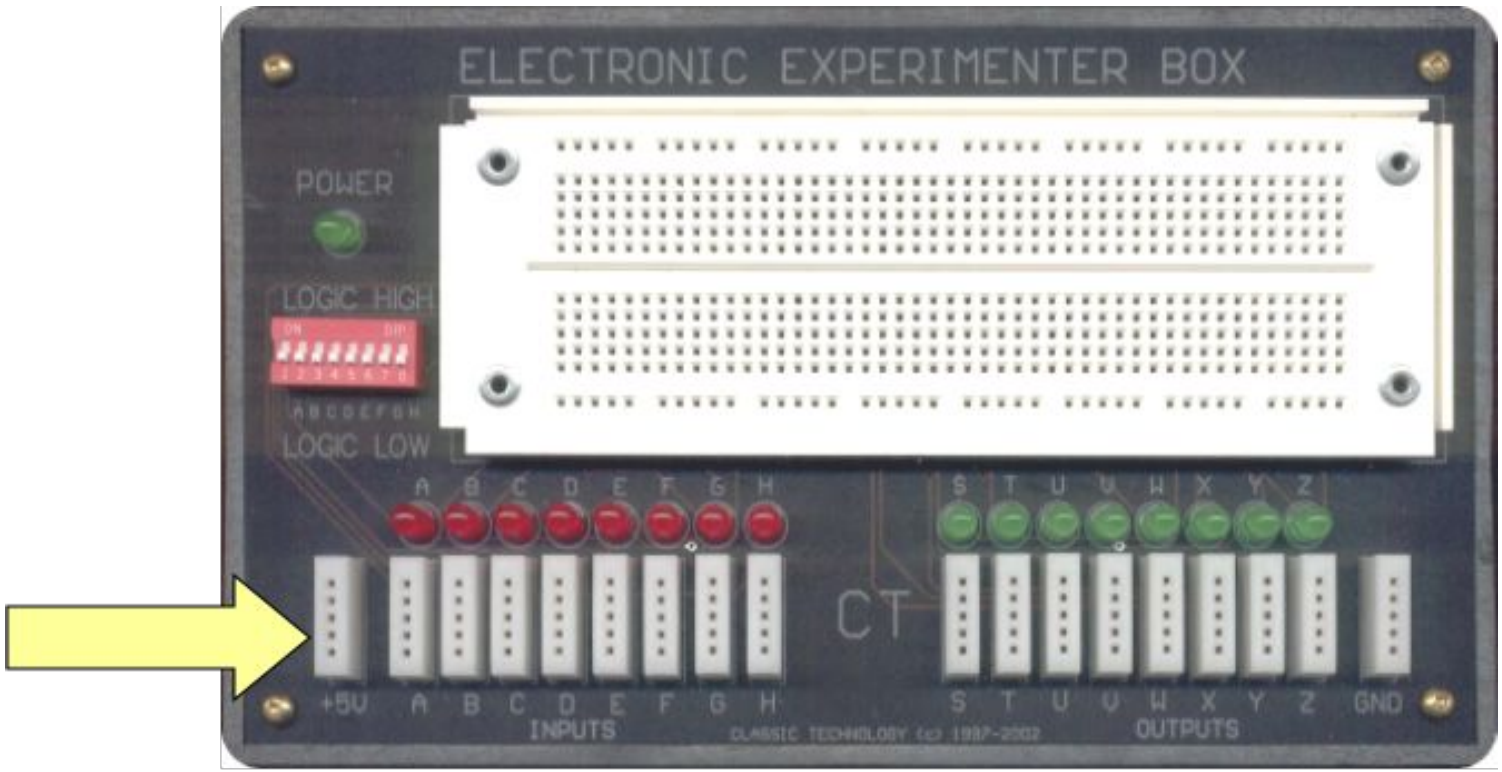
- A computer power supply



- 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)

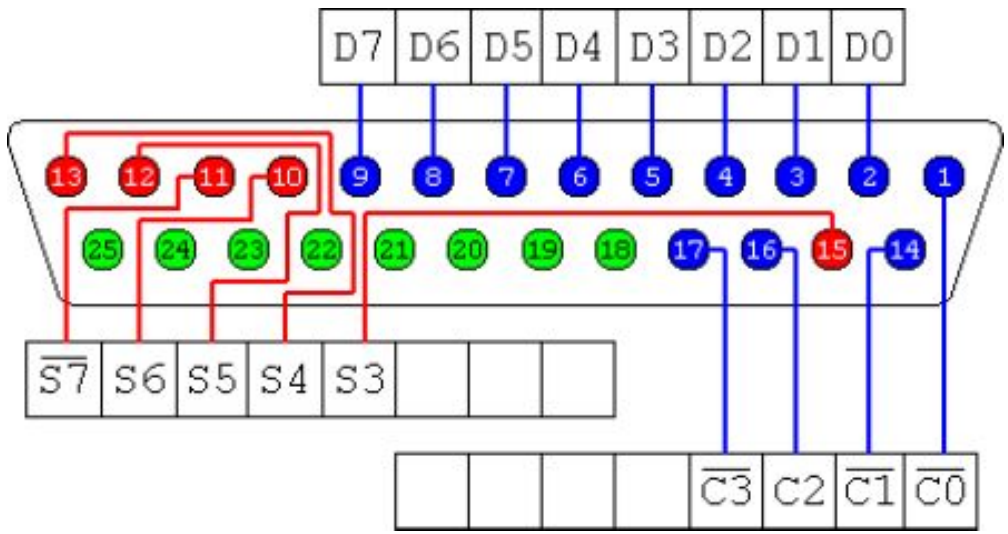
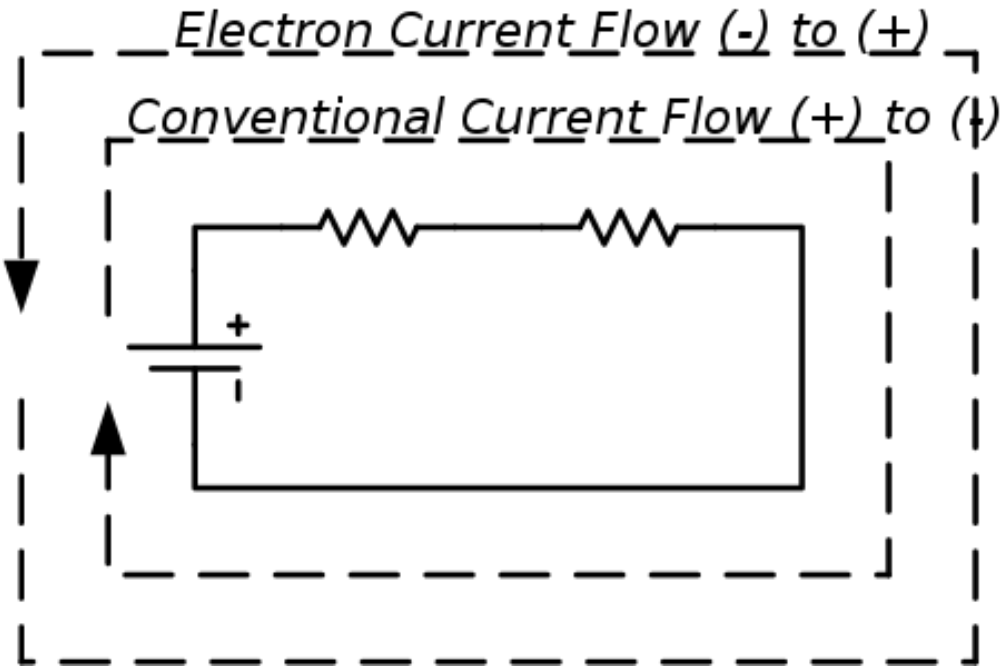


Diagram from
http://www.doc.ic.ac.uk/~ih/doc/par/

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)*



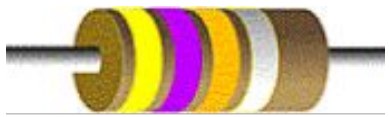
Resistors – Basic Specs

- Can be rated by…
  - Resistance (Ohms, □)
  - Tolerance (% of nominal value)
  - Power Rating (Watts)

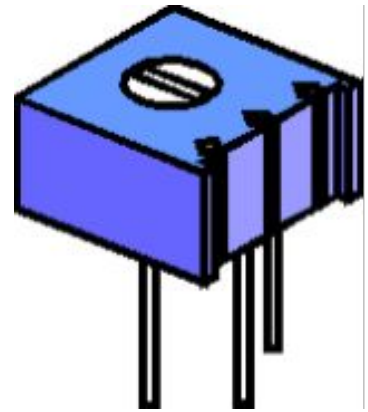
- Schematic Symbol…

Resistors – Types

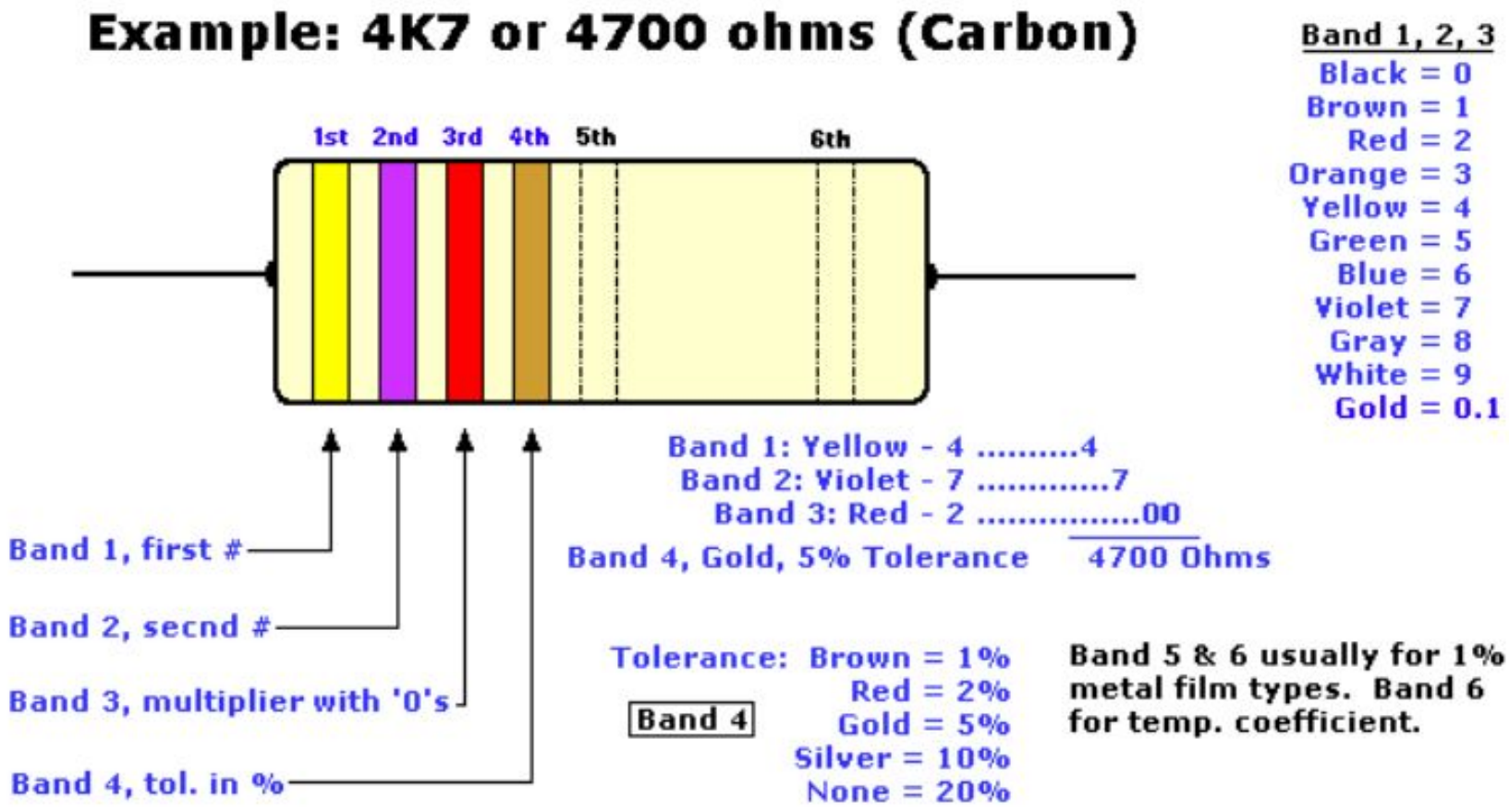
- Fixed



- Variable (Potentiometer, Rheostat)



Resistors – Colour Code



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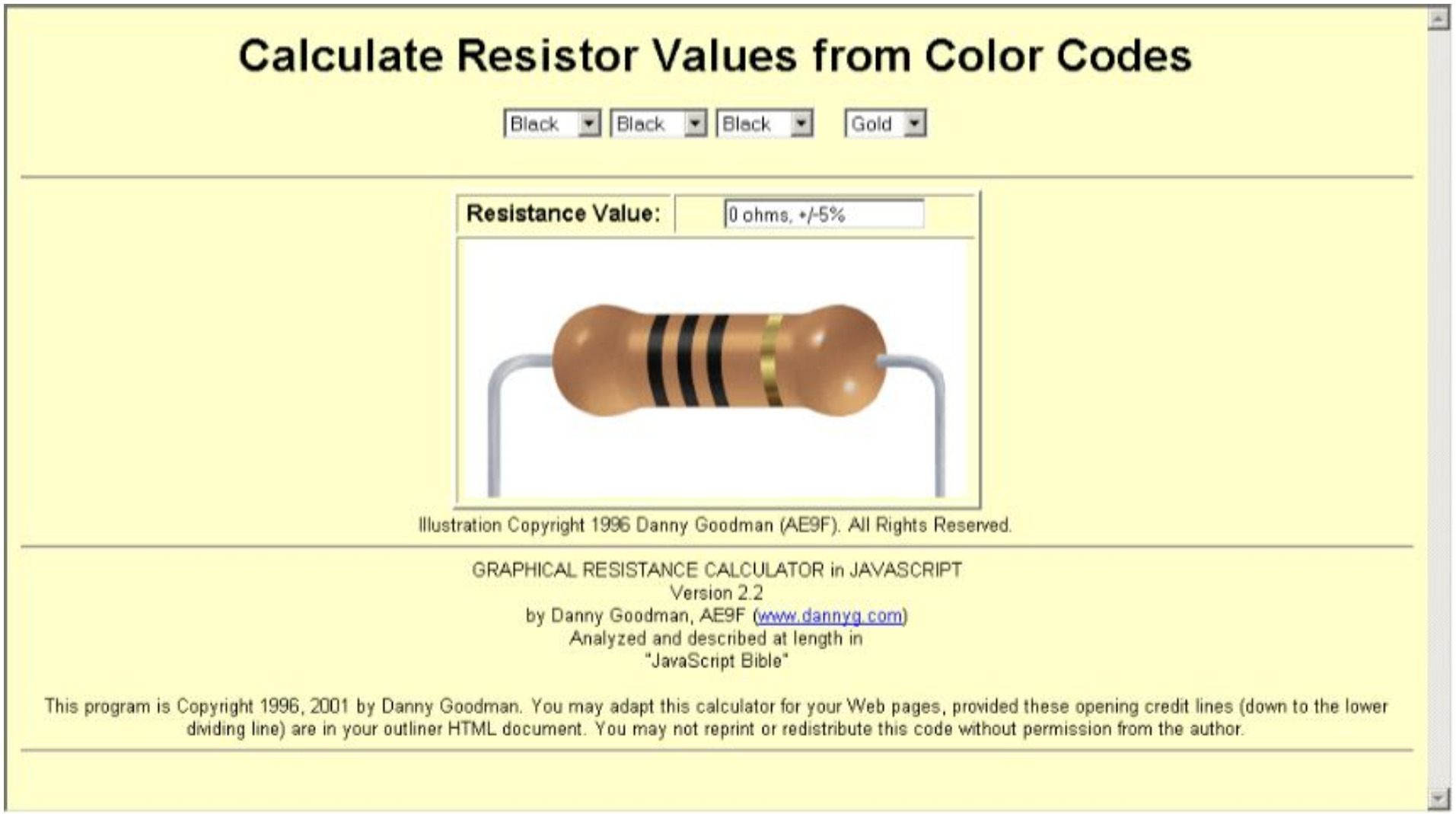
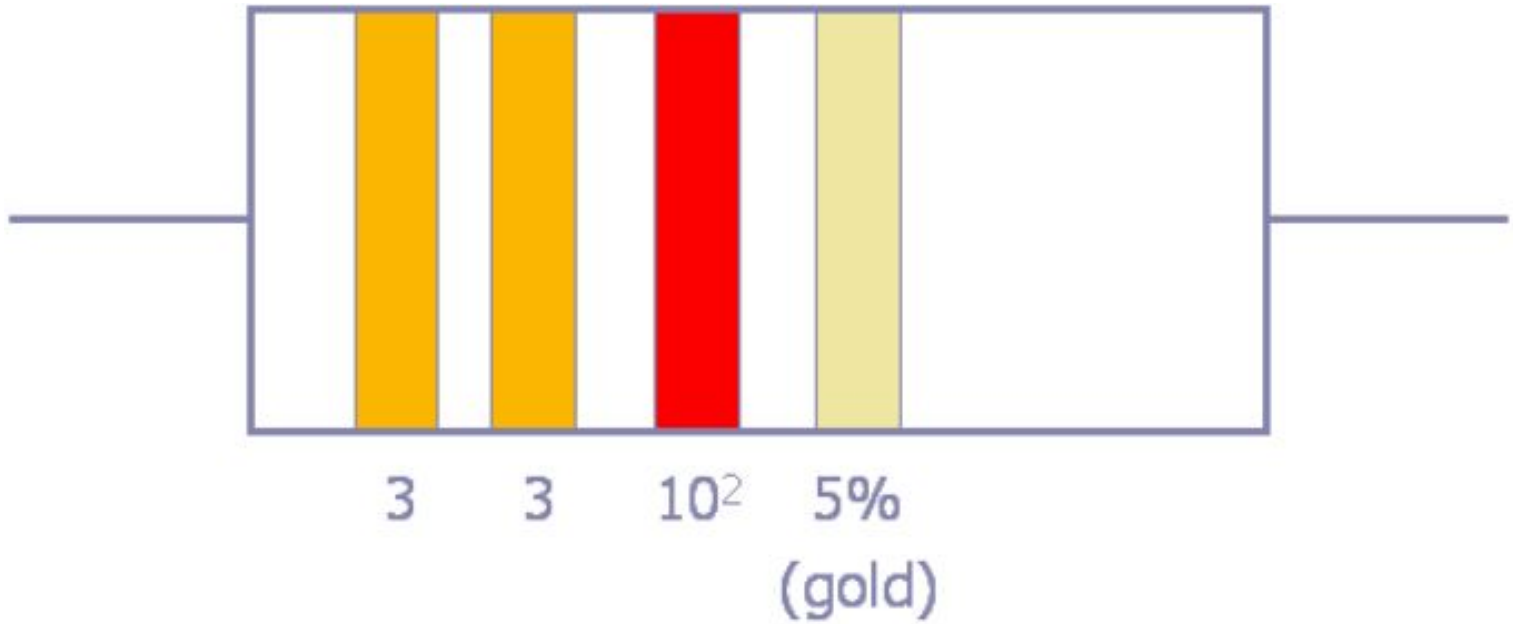
Resistors – Colour Code



Javascript Resistance Calculator available at

http://www.beens.org/misc/resCalc/resistor.ht

Resistors – Colour Code Example



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

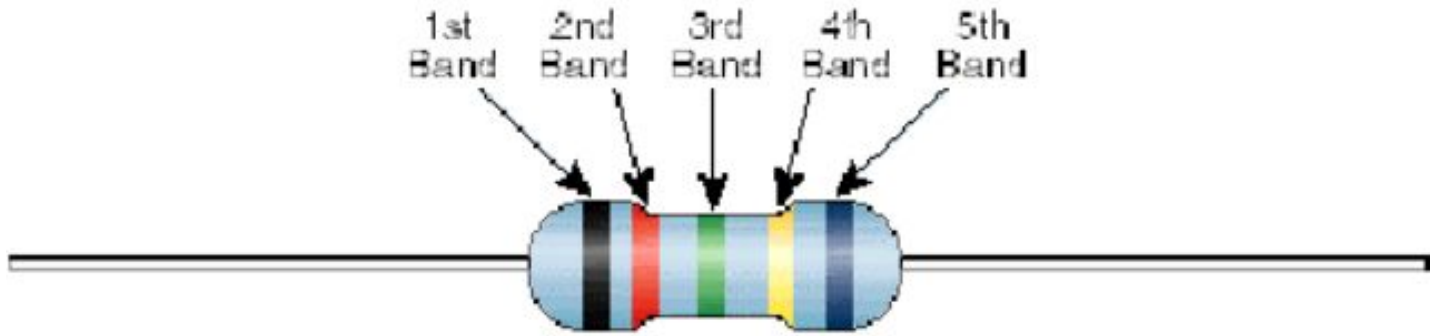
33×10^2

$= 3300\ \Omega$

$= 3.3\ k\Omega$

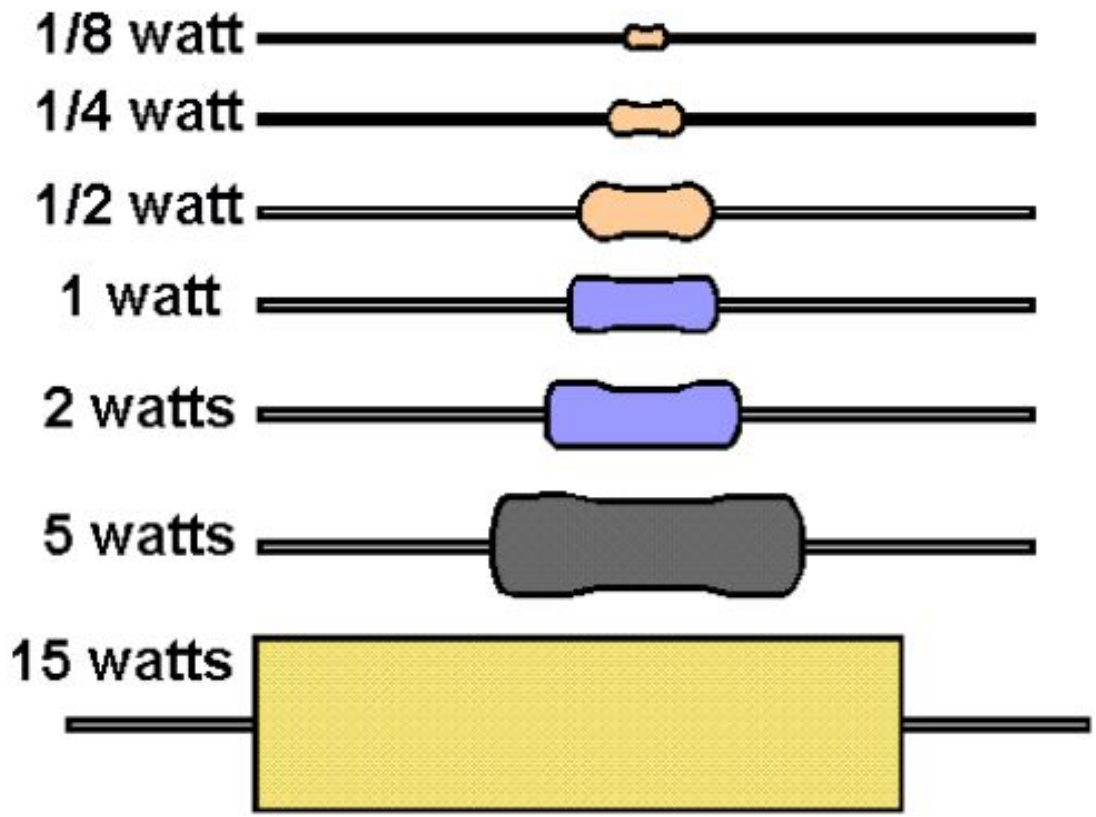
Resistors – 5 Band Colour Code

Standard EIA Color Code Table 5 Band: ±.1%, ±.25%, ±.5%, ±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	±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	±.5%
Blue	6	6	6	10^6	±.25%
Violet	7	7	7	10^7	±.1%
Gray	8	8	8	10^8	
White	9	9	9	10^9	
Gold				10^{-1}	

Resistors – Typical Power Ratings

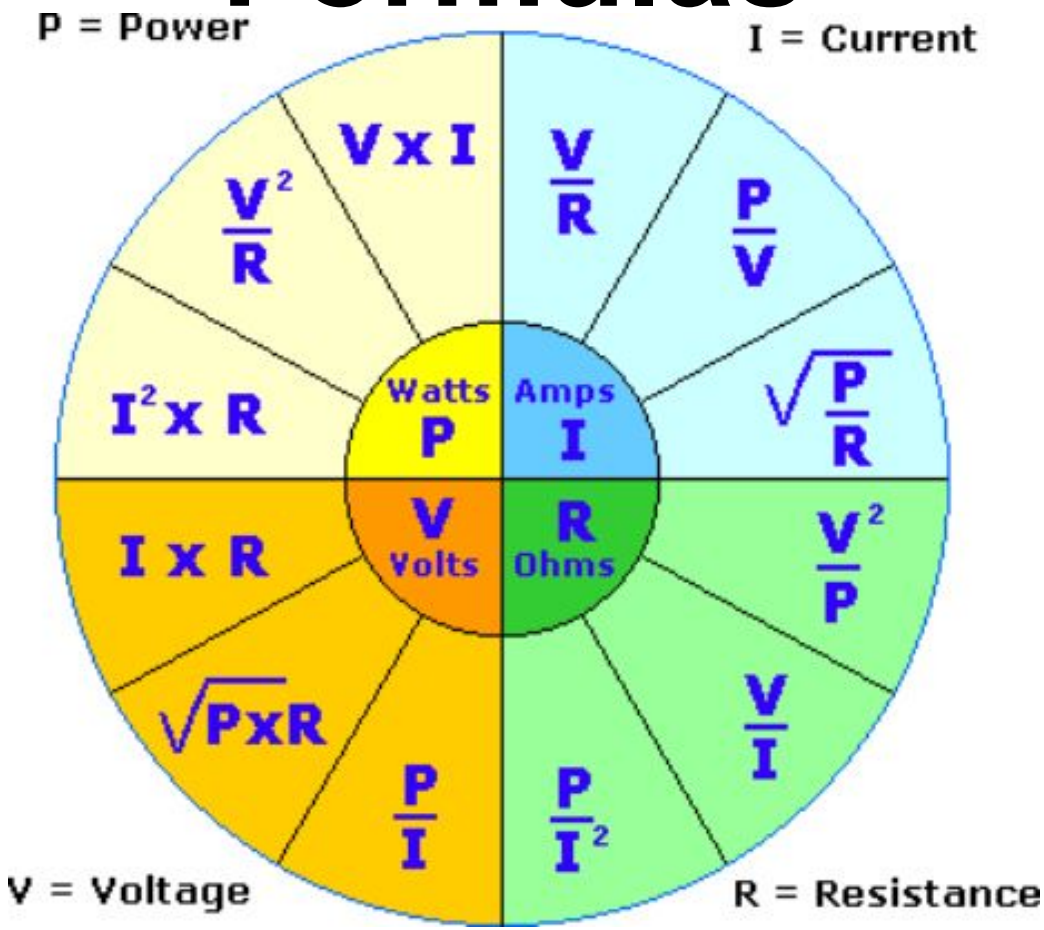


Ohm's Law

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

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

Ohm's Law and Power Formulas



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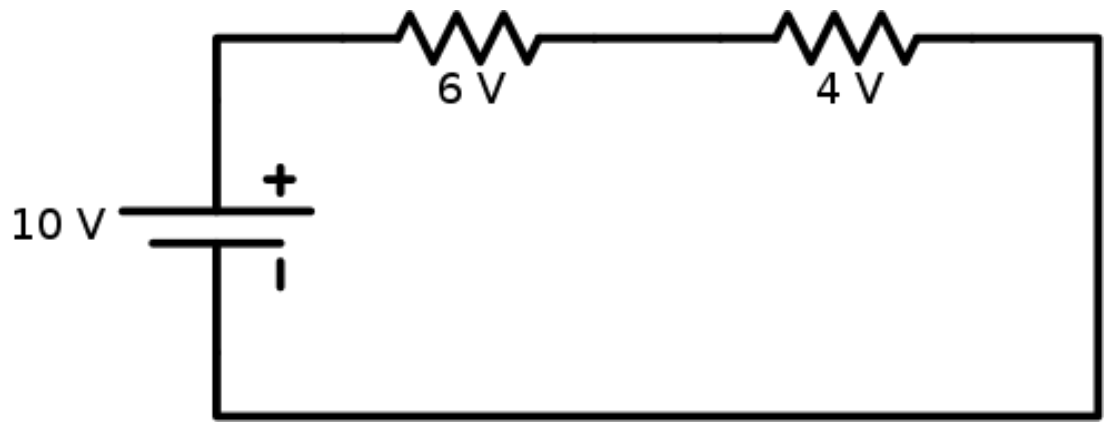
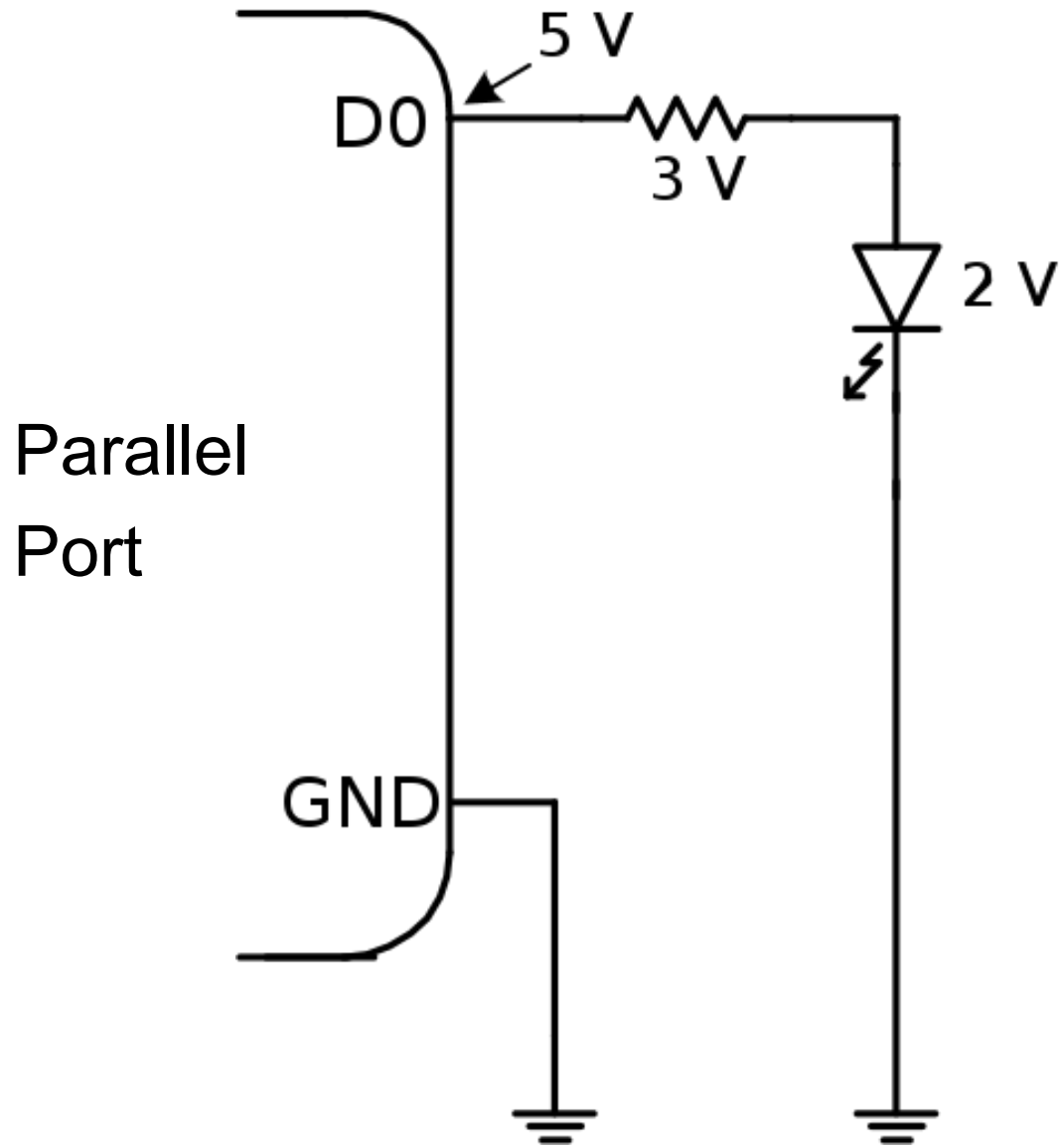
Kirchhoff's Voltage Law

- 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"

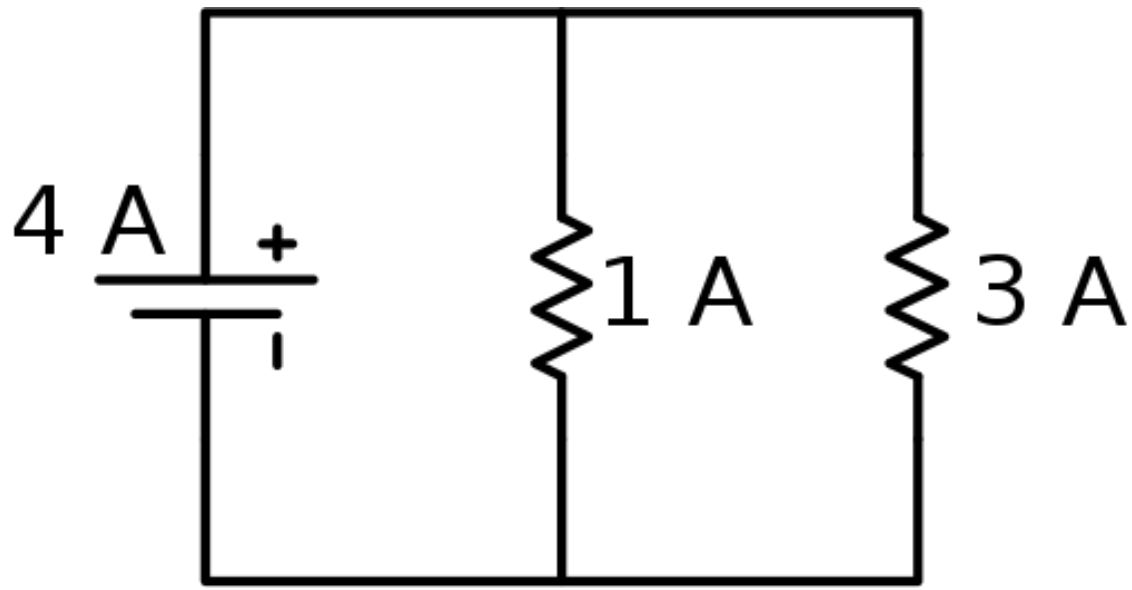


Kirchhoff's Voltage Law (cont'd)



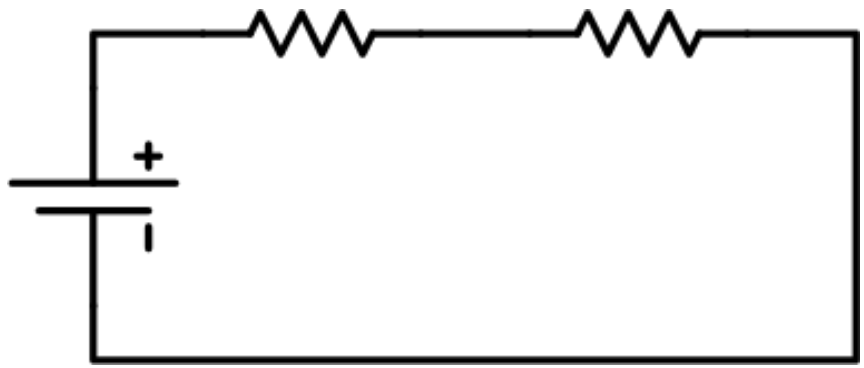
Kirchhoff's Current Law

- 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

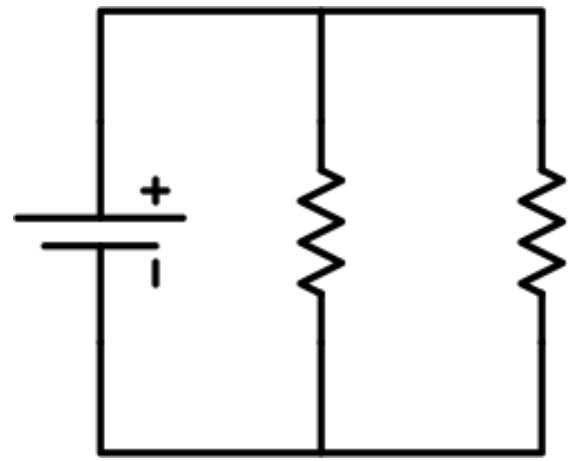


- Total resistance is the sum of the individual resistances

$$R_T = R_1 + R_2 + \ldots$$

Parallel Circuits

- More than one current path



- Total current is the sum of the individual currents

$$I_T = I_1 + I_2 + \ldots$$

Parallel Circuits (cont'd)

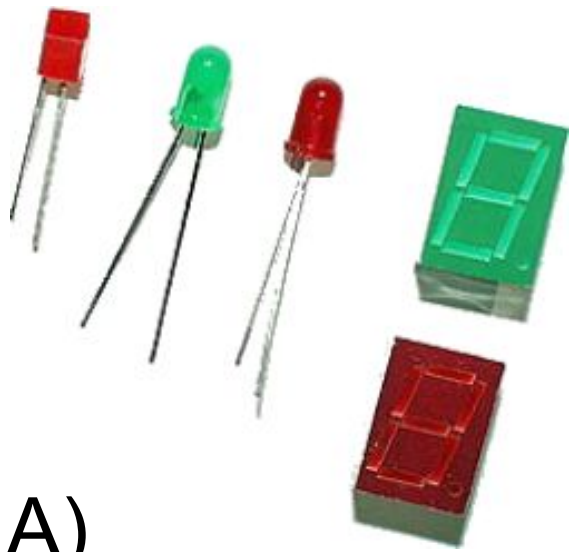
$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

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

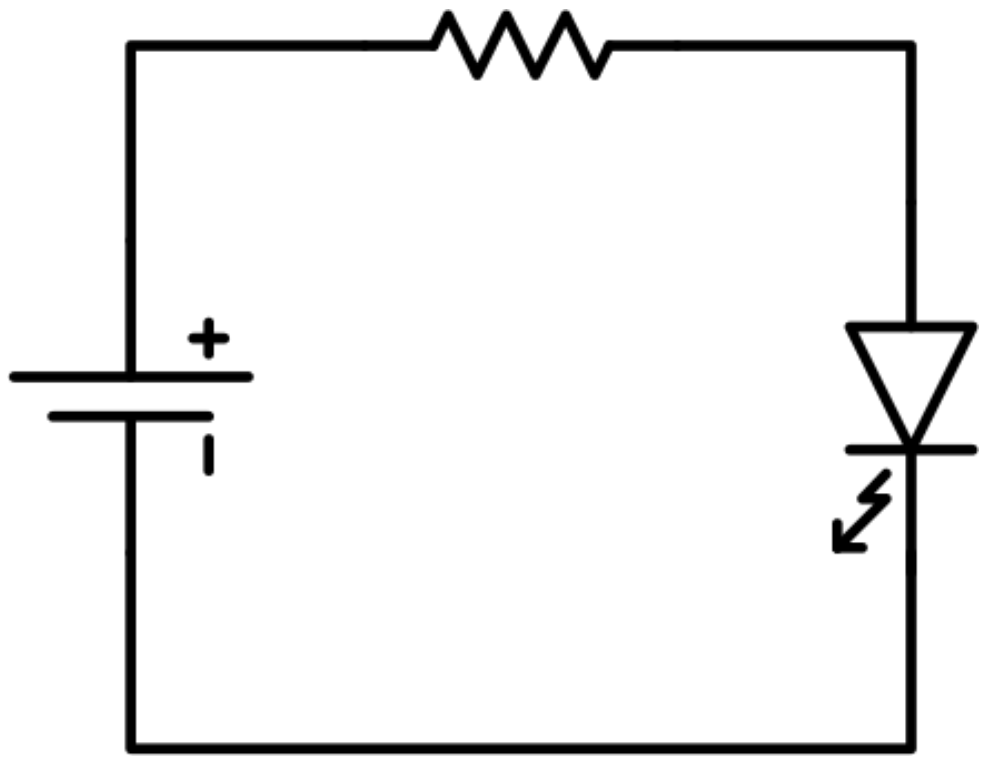
$$R_T = \frac{R}{n} (if\ the\ same\ value)$$

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



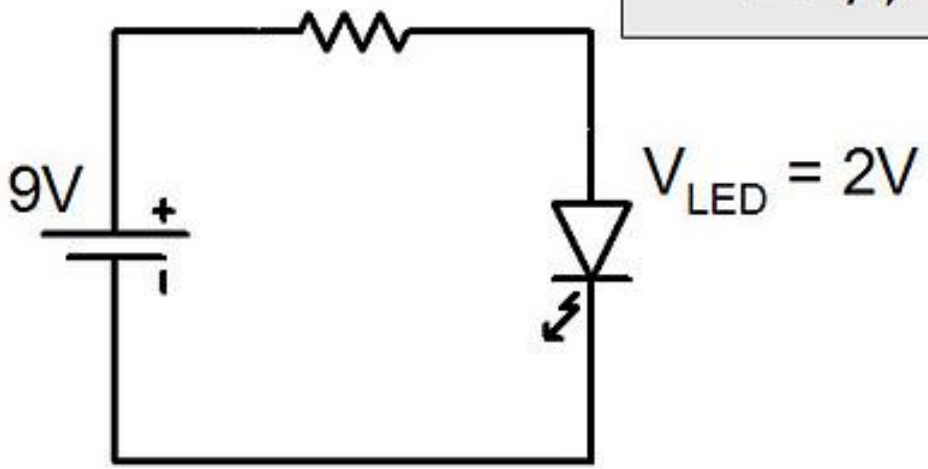
Analyzing a LED Circuit with KVL and Ohm's Law

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

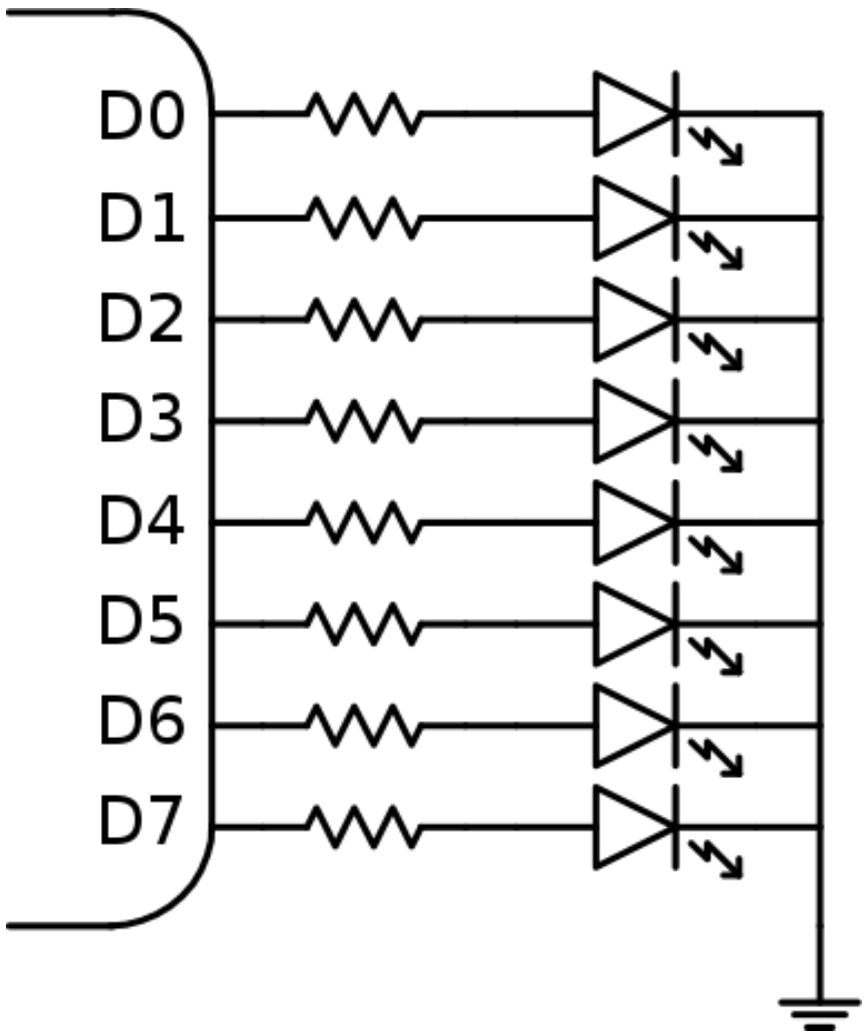
$$V_R = V_T - V_{LED}$$
$$= 9 - 2$$
$$= 7V$$

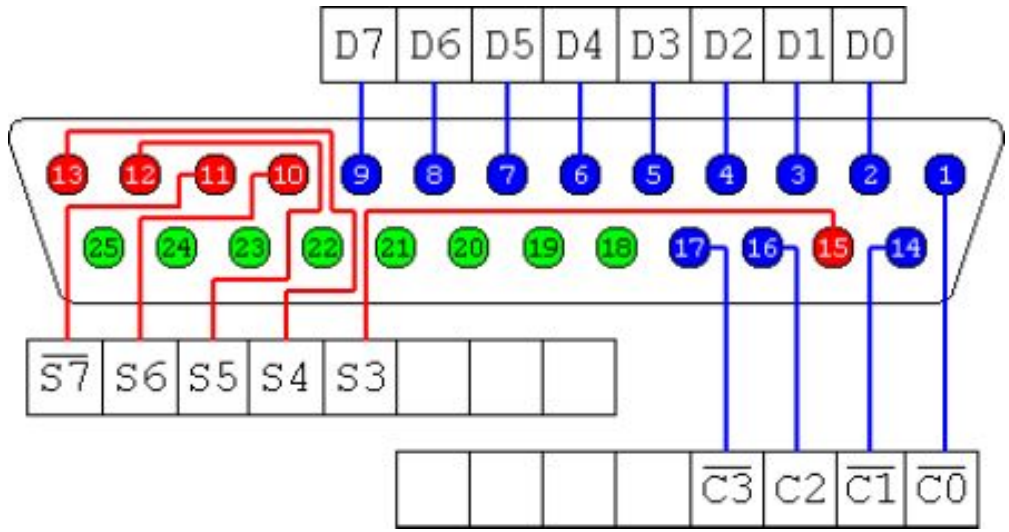
$$I_{LED} = I_R = 20\,mA$$

$$R = \frac{V_R}{I_R}$$
$$= \frac{7\,V}{0.020\,\,A}$$
$$= 350\,\,\Omega$$



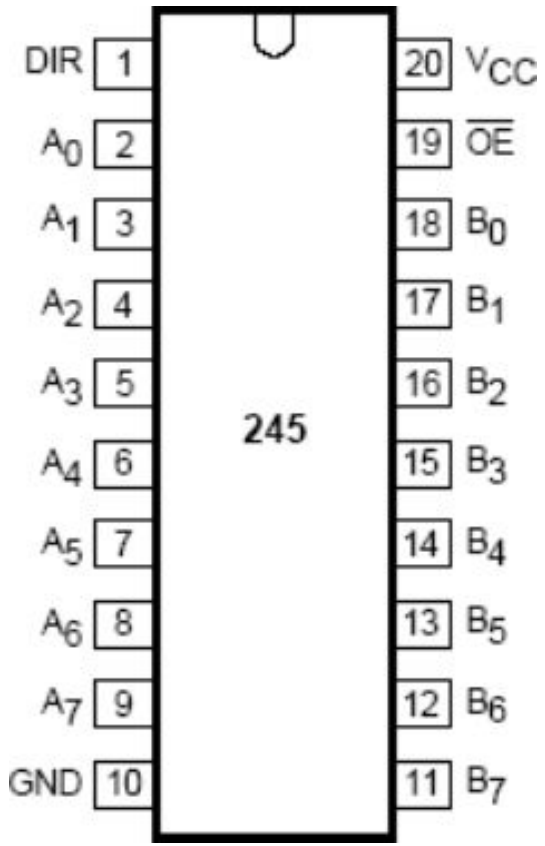
Interfacing LEDs to the Parallel Port



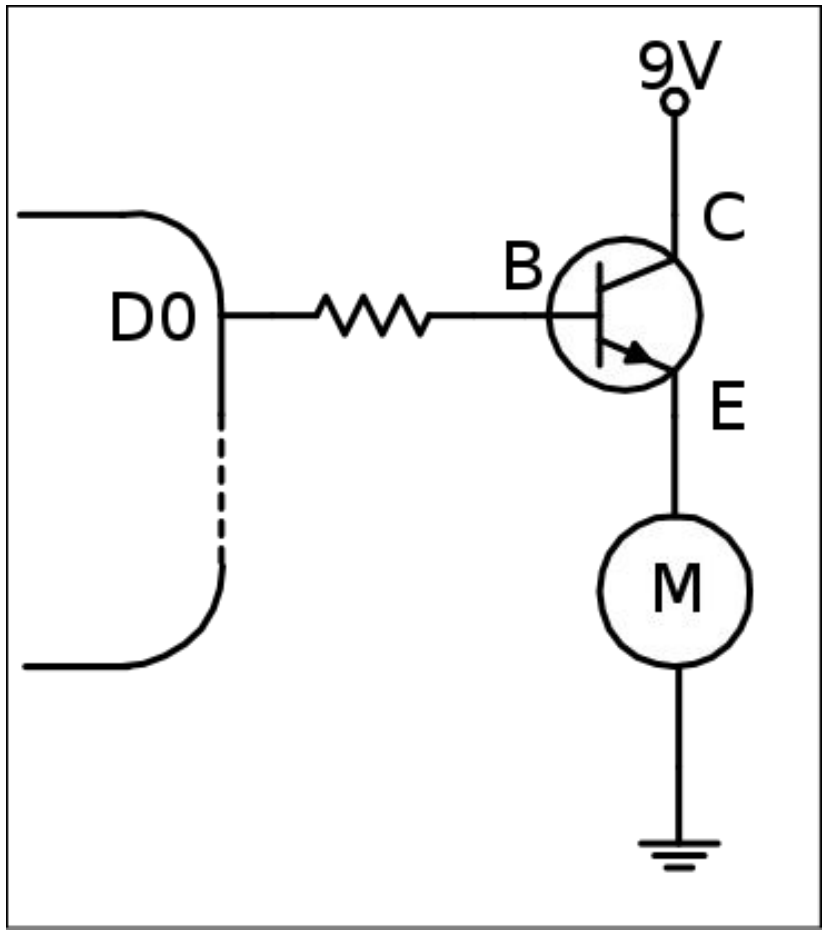


Protecting the Parallel Port

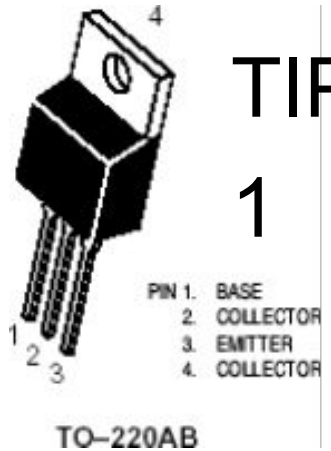
- Use a 74LS245 “Octal Bus Transceiver” to protect the computer parallel port



Interfacing a Motor to the Parallel Port



2N3904

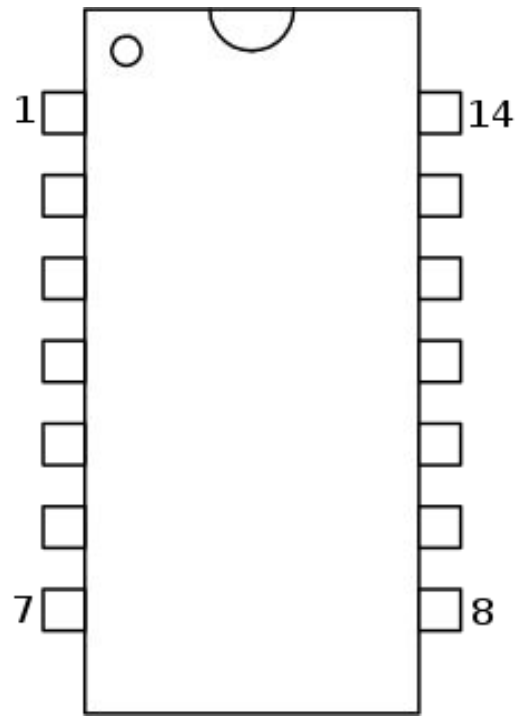


TIP31

(A stepper motor would require more outputs)

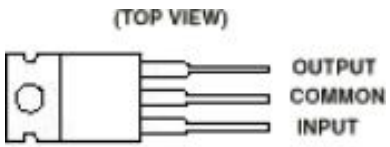
Integrated Circuits

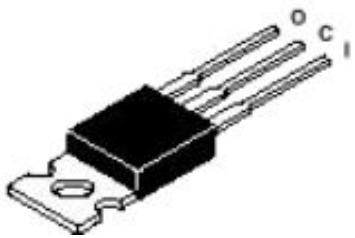
- 7400 series typically used for logic gate experiments (AND, OR, etc.)
- Very susceptible to voltage variations and static discharge
- Note pin 1 on diagram
- Refer to applicable data-sheet for pinouts



7805 Voltage Regulator

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





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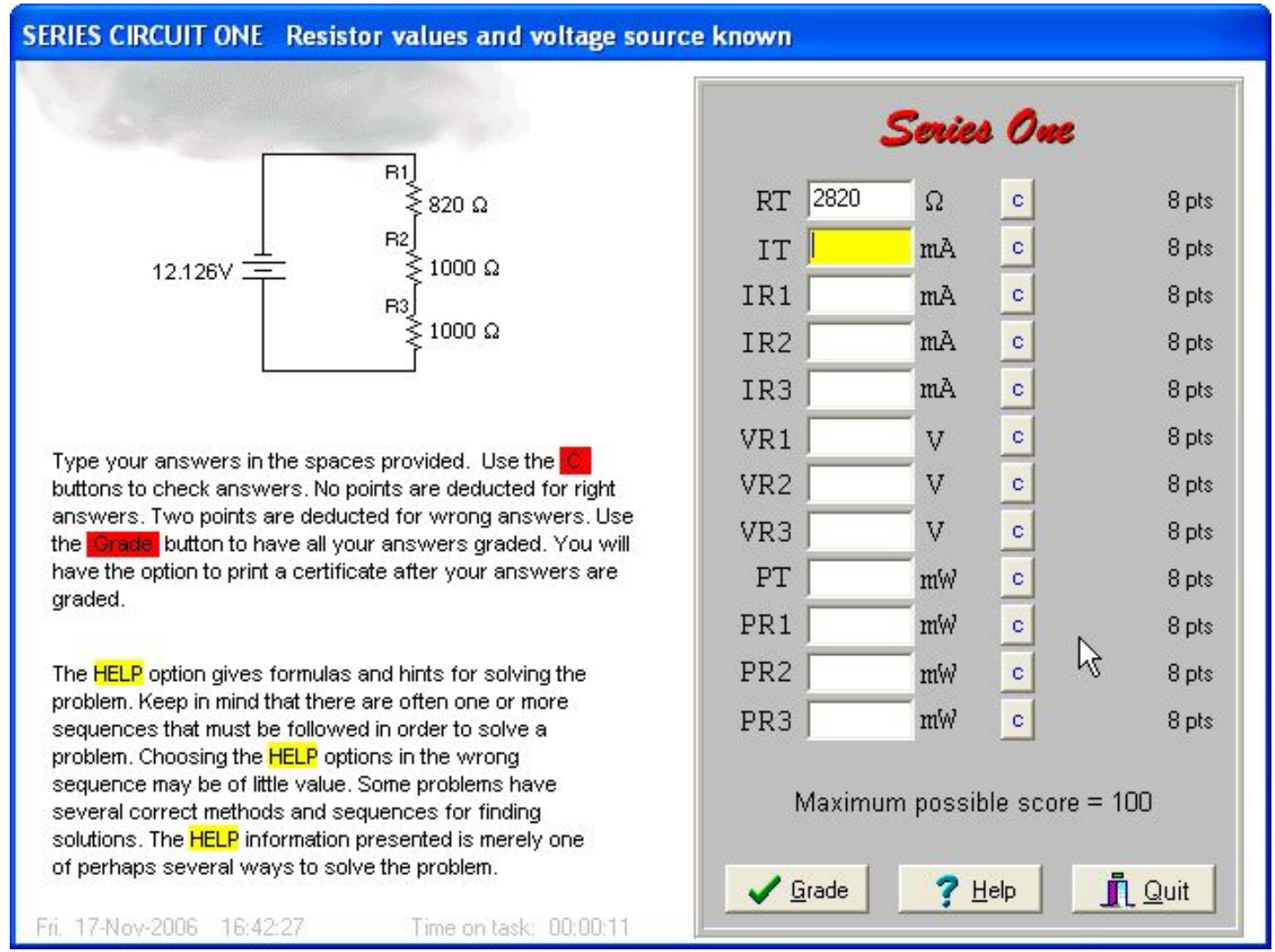
http://ohmslaw.com/Steps.htm

Electronics Software - ETCAI

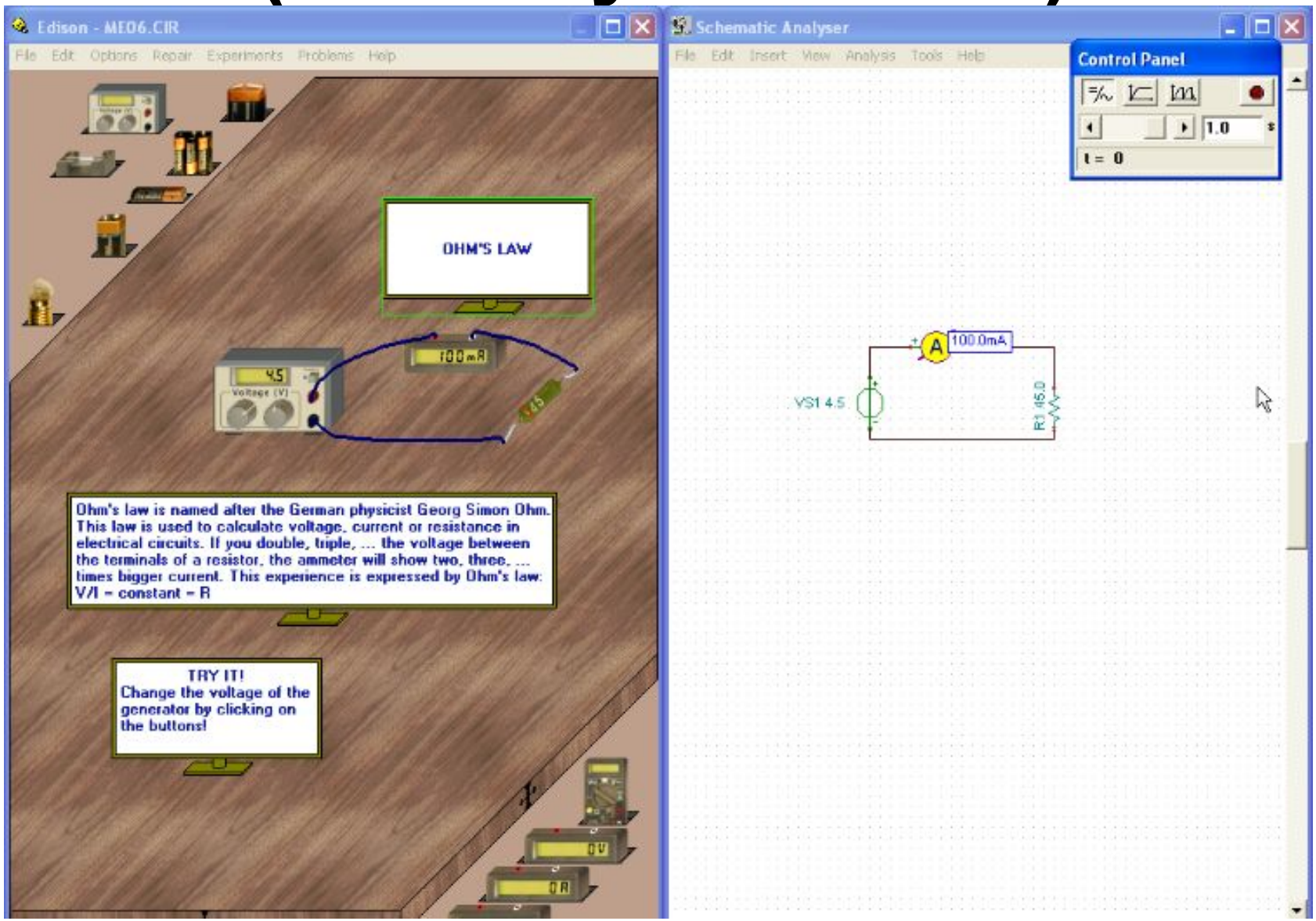
$229 US per module.

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

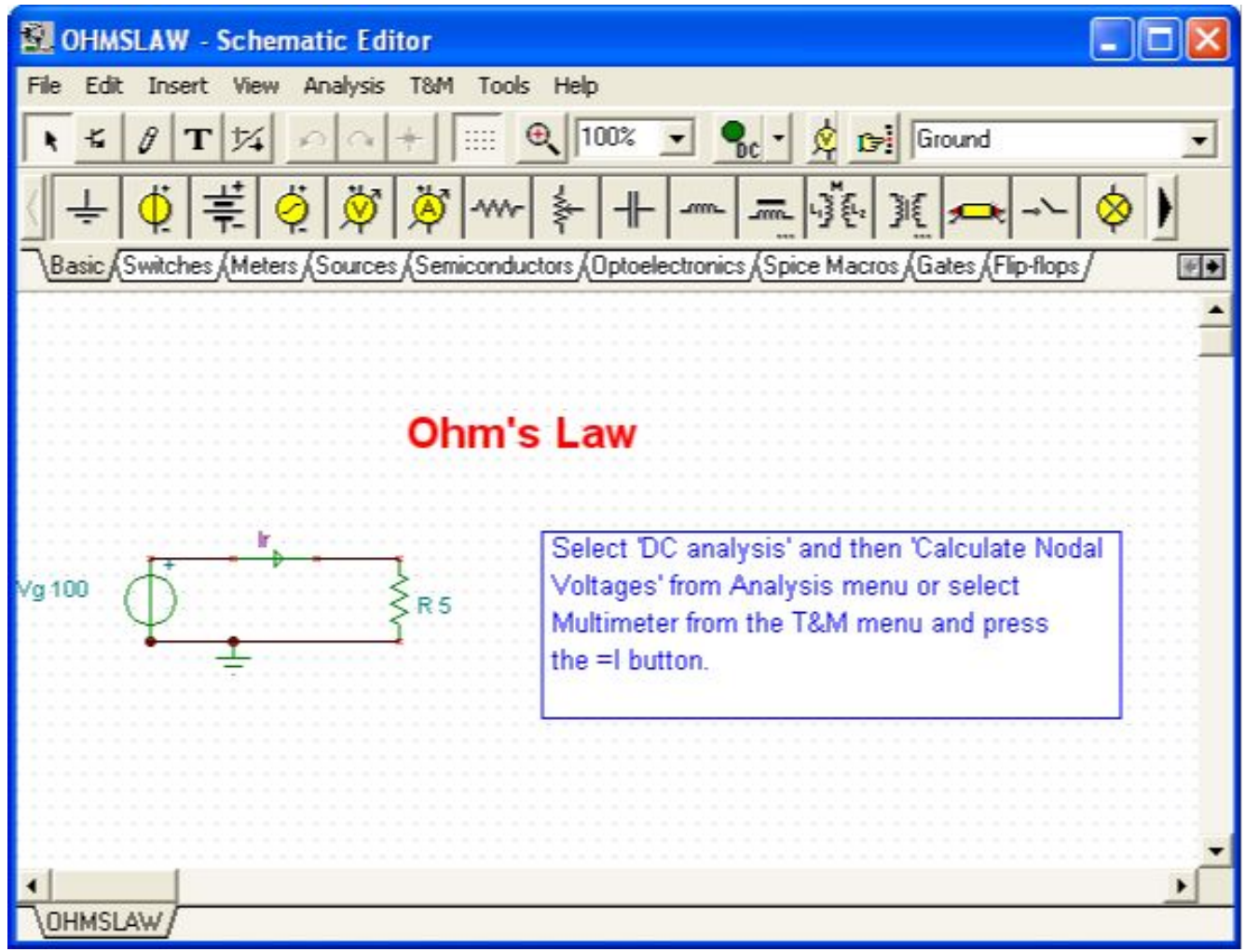
Available from www.etcai.com/



Electronics Software – Edison (Ministry-licensed)

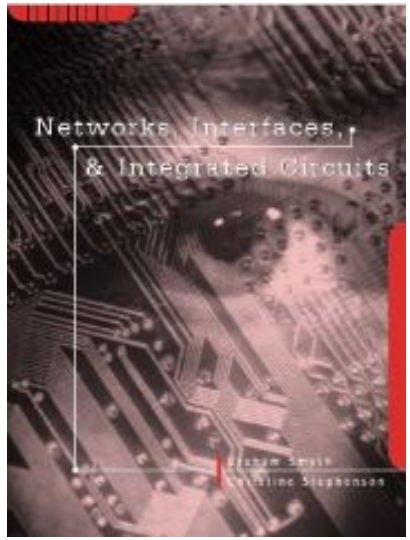


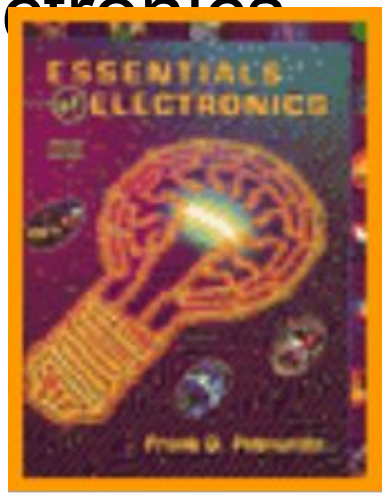
Electronics Software – Tina (Ministry-licensed)



Textbook References

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





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>
  - http://www.doc.ic.ac.uk/~ih/doc/par/
  - Used with permission
- Trainer Picture
  - classic@classictech.on.ca (London, ON)
  - http://www.classictech.on.ca/
  - Used with permission
- Resistor Power Ratings Diagram
  - Quality RF Services, Inc.
  - http://www.qrf.com/

Credits (cont'd)

- Holt Software Pictures
  - http://www.holtsoft.com/
  - Used with permission
- 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
  - Used with permission

Contact Info…

- Peter Beens
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- Email: 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	$2 = 1$