

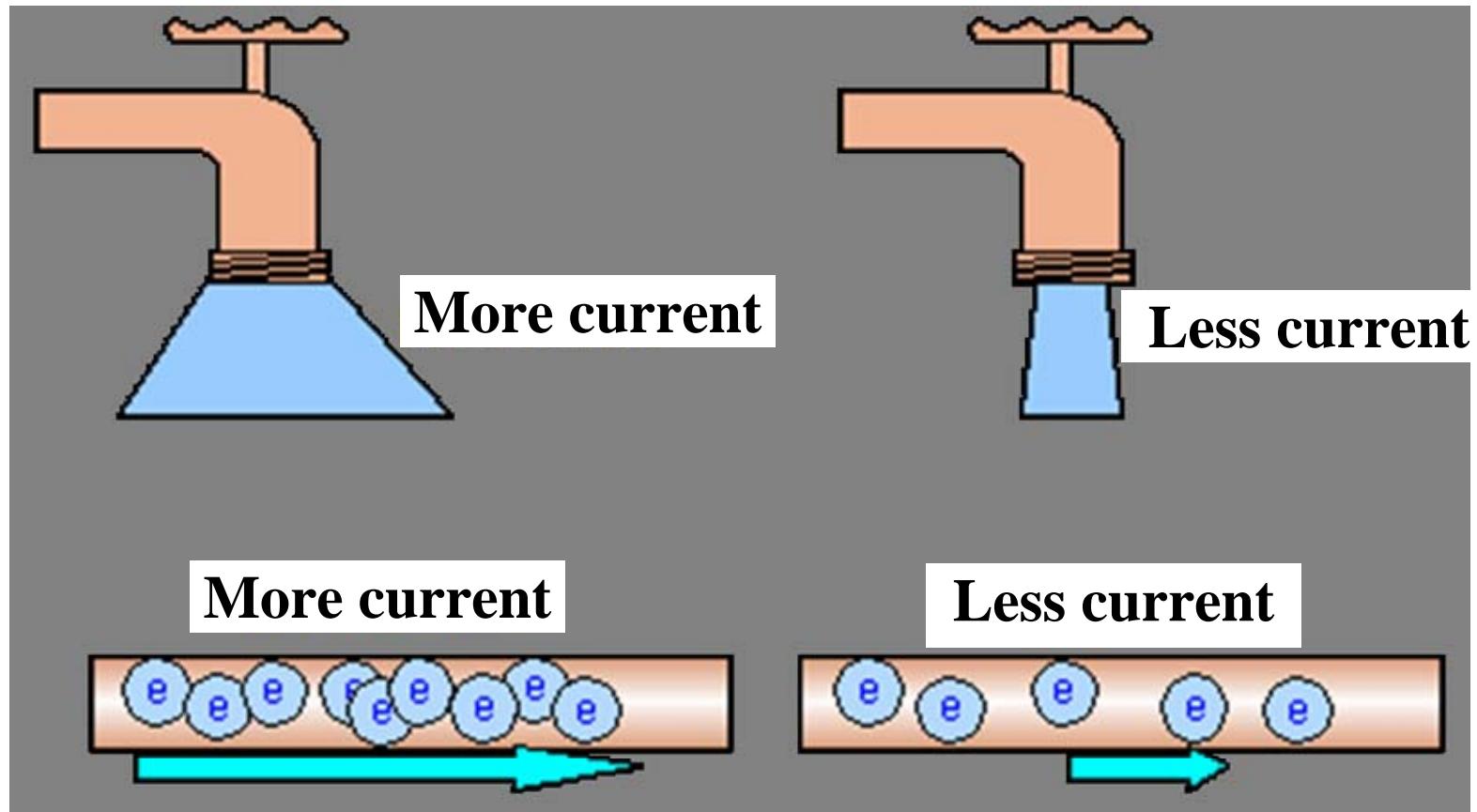
# Lecture 1

## Resistor

# What is Current?

- A flow of electrically charged particles
- Carried by small negatively-charged particles, called **electrons**
- Represented by the symbol  $I$ , and is measured in **amperes**, or 'amps', A
- Most often measured in **millamps**, mA
- Like water flow

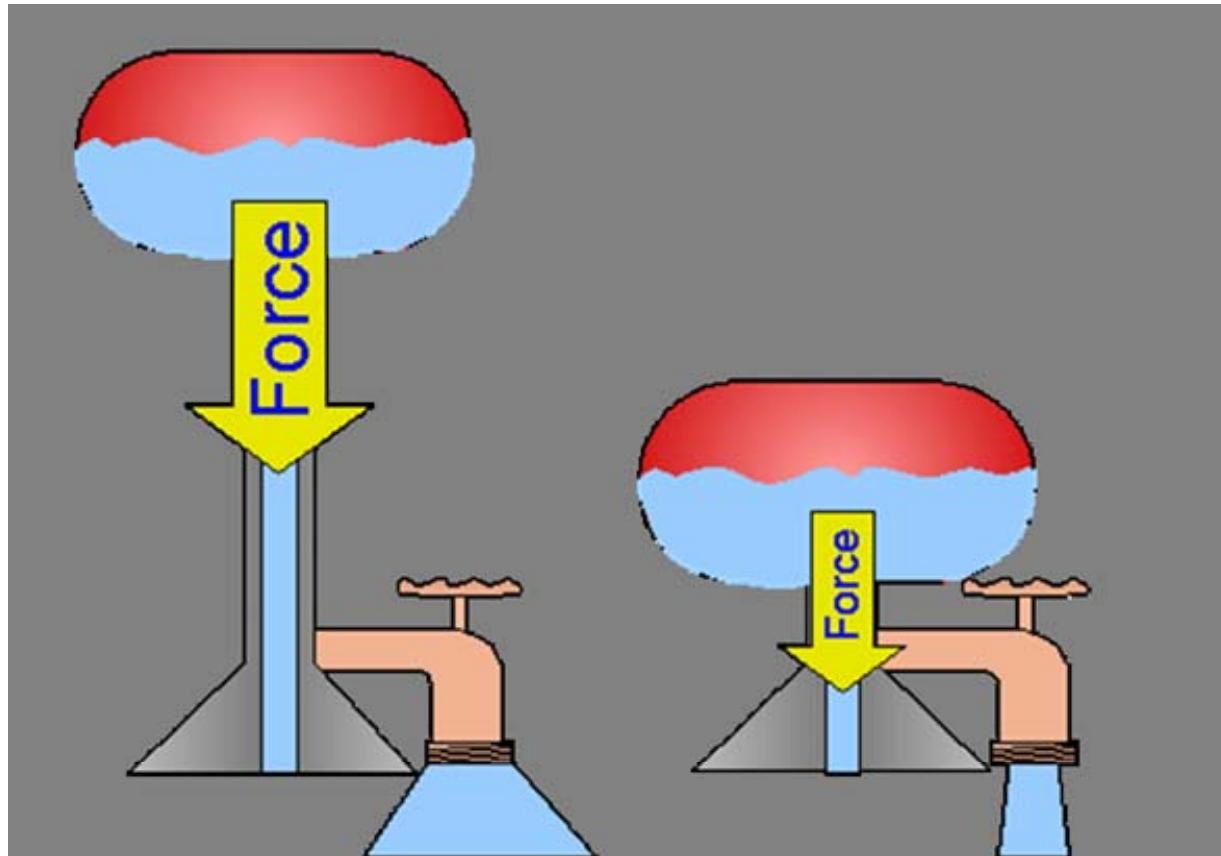
# Water Analogy



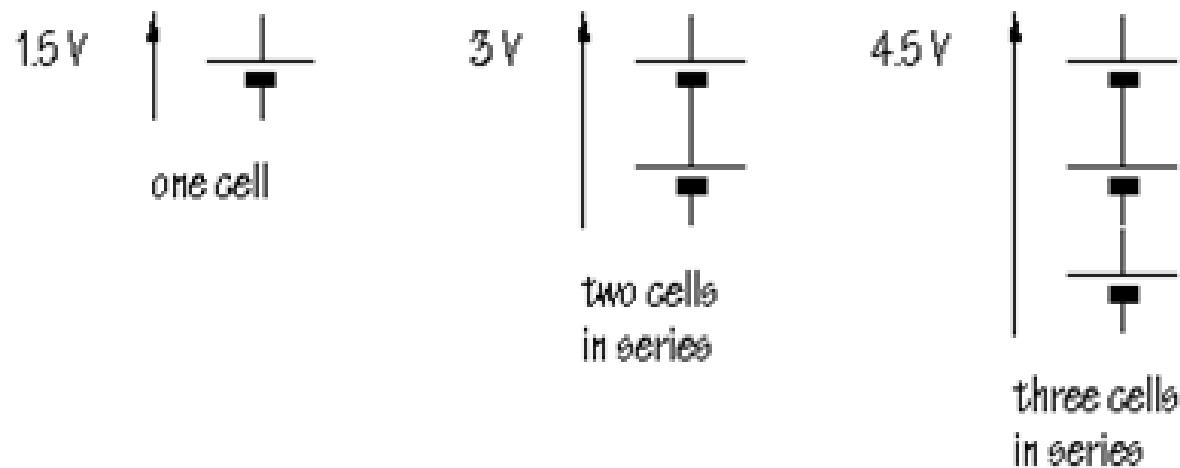
# What is Voltage?

- **Potential difference**
- Represented by the symbol  $V$ , and is measured in volts,  $V$
- Like potential energy at water fall

# Water Analogy

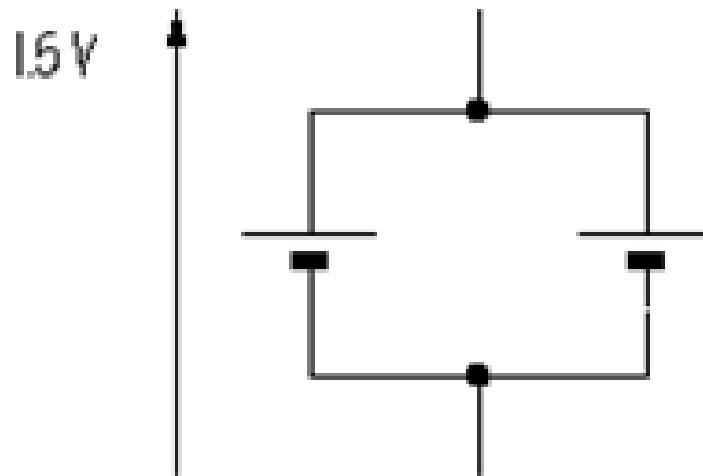


# Series Connection of Cells



- Each cell provides 1.5 V
- Two cells connected one after another, **in series**, provide 3 V, while three cells would provide 4.5 V
- Polarities matter

# Parallel Connection of Cells



- If the cells are connected in parallel, the voltage stays at 1.5 V, but now you can draw a larger current

# DC and AC

- A cell provides a steady voltage, so that current flow is always in the same direction
  - This is called **direct current**, or **d.c**
- The domestic mains provides a constantly changing voltage which reverses in polarity 60 times every second
  - This gives rise to **alternating current**, or **a.c**

# Power Supply

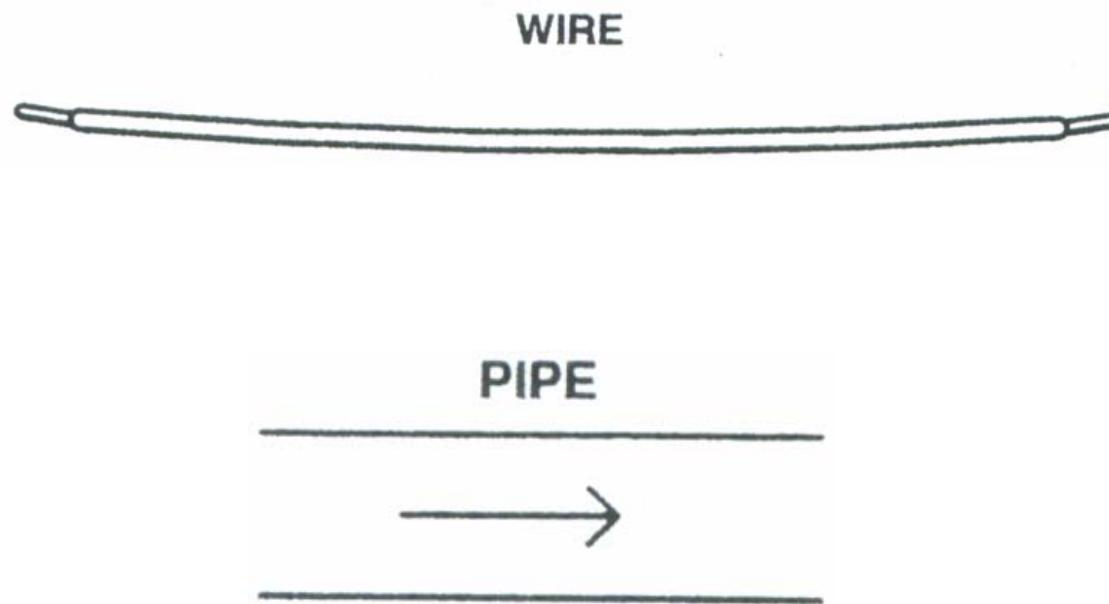


Digital



Analog

# Water Analogy of Wires

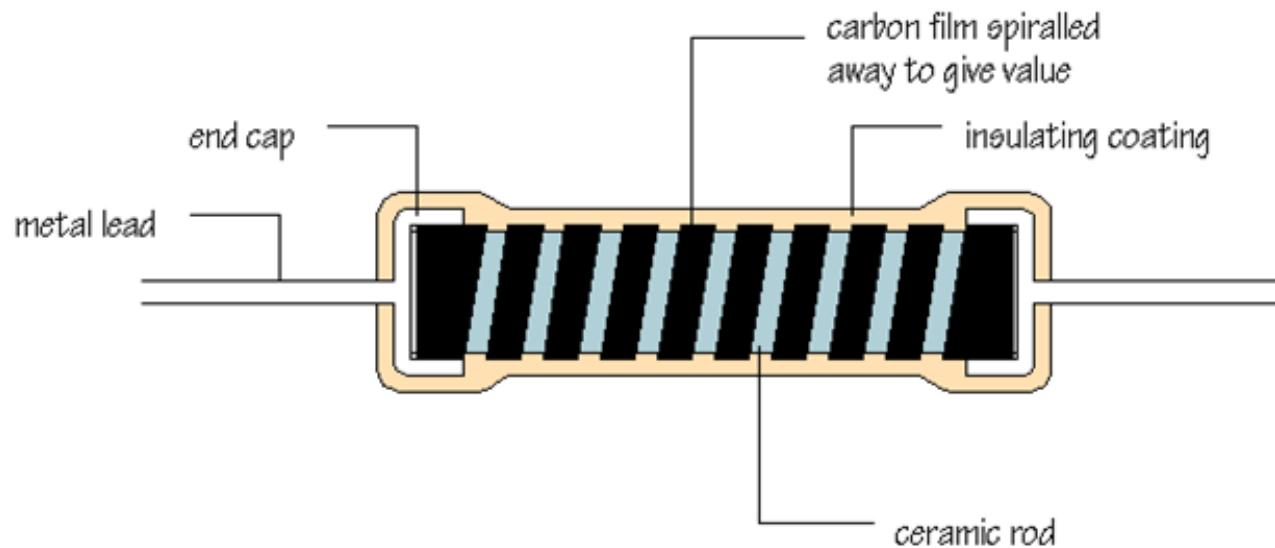


# Resistors

- Dissipative elements that convert electrical energy into heat
- Resistors limit current
- Unit is **ohms**,  $\Omega$

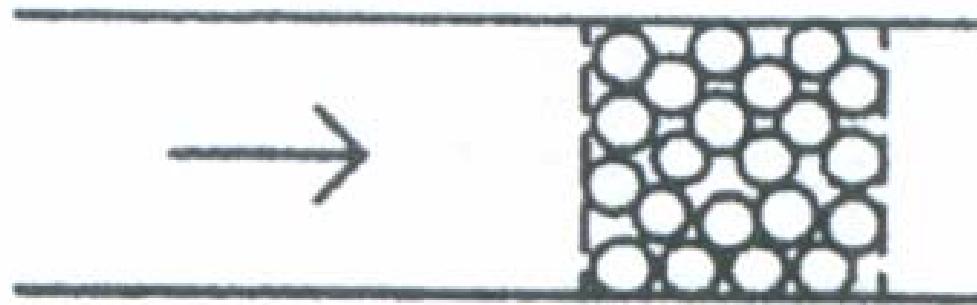


**Resistor Symbols**



# Water Analogy of Resistor

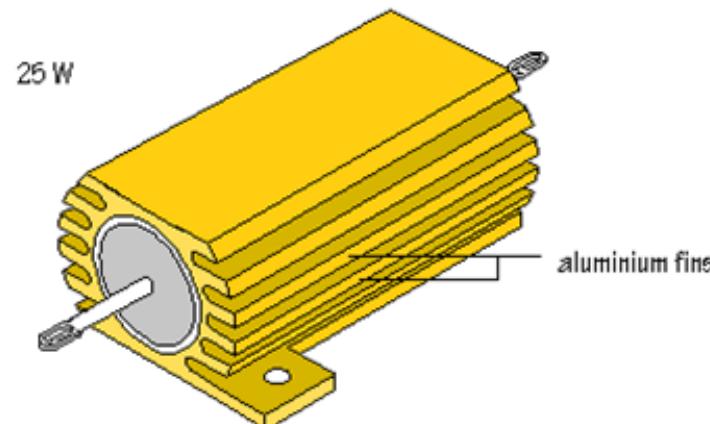
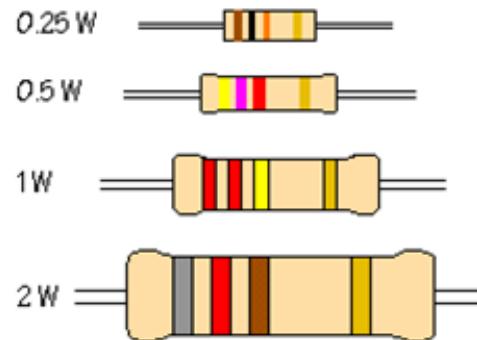
**ROCKS IN THE PIPE**



# Resistor Applications

- Resistors are used for
  - Limiting current
  - Lowering voltage (voltage divider)
  - As current divider
  - As a sensor (potentiometers, photoresistors, strain gauge)
  - As pull-up or pull down elements

# Resistors of Different Sizes

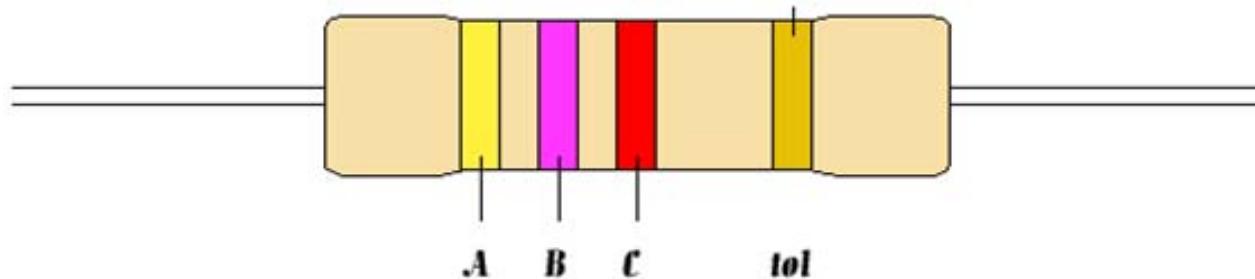


# How to Read Resistor Values 1

1. By color code
2. By digital multi meter (DMM)

# How to Read Resistor Values 2

## By color code



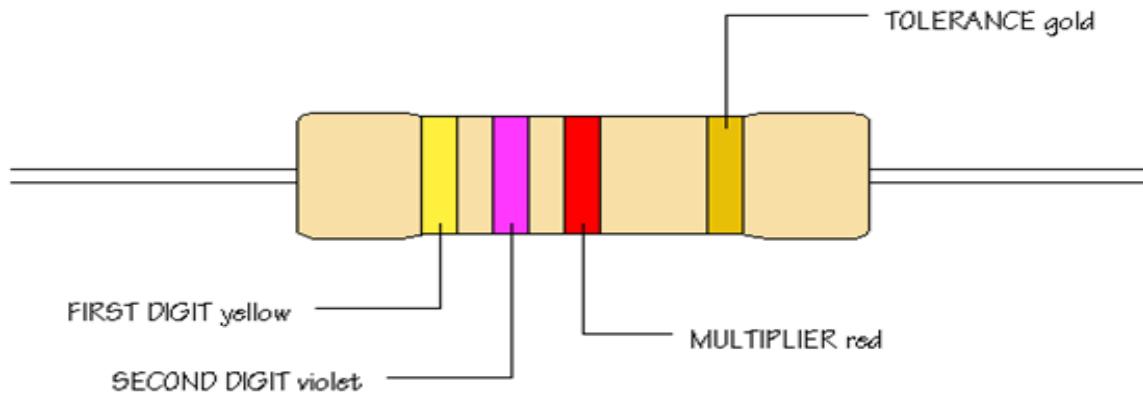
$$\text{Resistor value} = AB \times 10^C \pm tol\% (\Omega)$$

# Resistance Color Code

<i>Number</i>	<i>Color</i>
0	black
1	brown
2	red
3	orange
4	yellow
5	green
6	blue
7	violet
8	grey
9	white

<i>Tolerance</i>	<i>Color</i>
$\pm 1\%$	brown
$\pm 2\%$	red
$\pm 5\%$	gold
$\pm 10\%$	silver

# Example

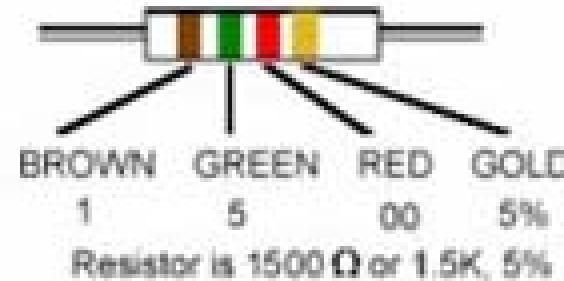
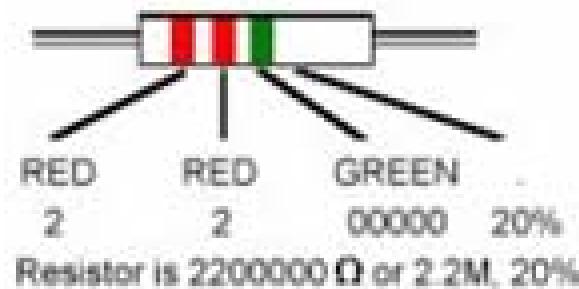
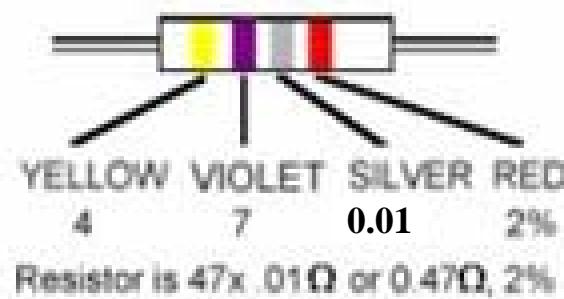


- The first band is yellow, so the first digit is 4
- The second band is violet, so the second digit is 7
- The third band is red, so the multiplier is  $10^2$
- Resistor value is  $47 \times 10^2 \pm 5\% (\Omega)$

# Metric Units and Conversions

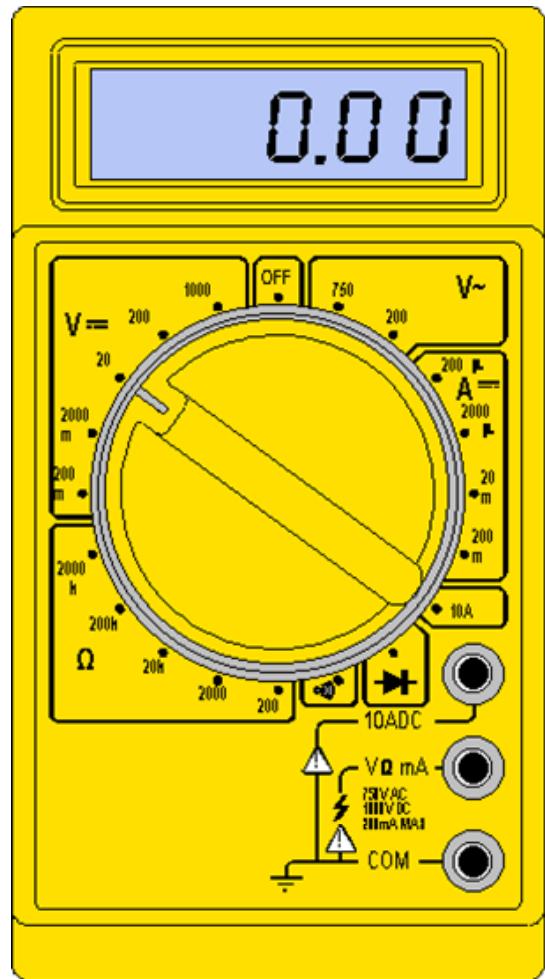
Abbreviation	Means	Multiply unit by	Or
p	pico	.000000000001	$10^{-12}$
n	nano	.000000001	$10^{-9}$
$\mu$	micro	.000001	$10^{-6}$
m	milli	.001	$10^{-3}$
.	Unit	1	$10^0$
k	kilo	1,000	$10^3$
M	mega	1,000,000	$10^6$
G	giga	1,000,000,000	$10^9$

# Examples



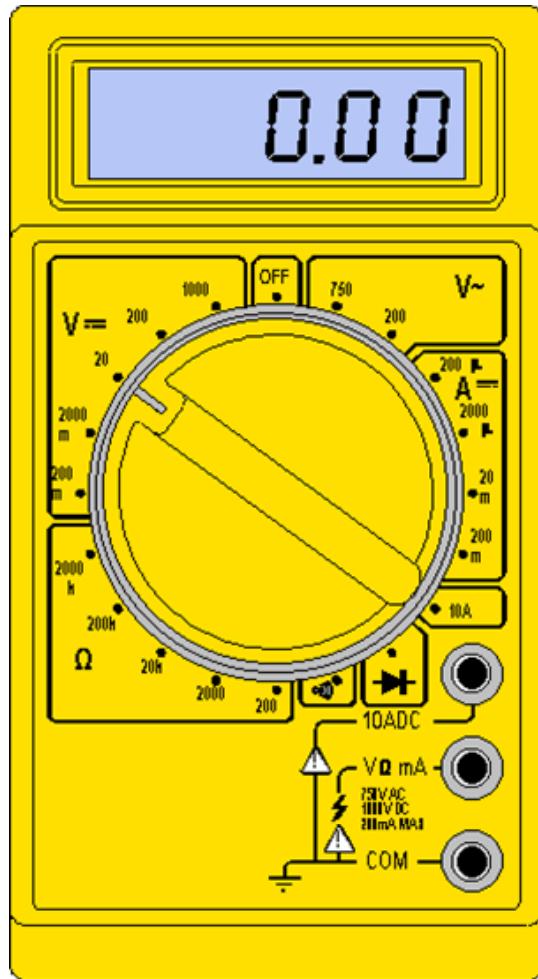
[http://www.electrician.com/resist\\_calc/resist\\_calc.htm](http://www.electrician.com/resist_calc/resist_calc.htm)

# Digital Multimeter 1



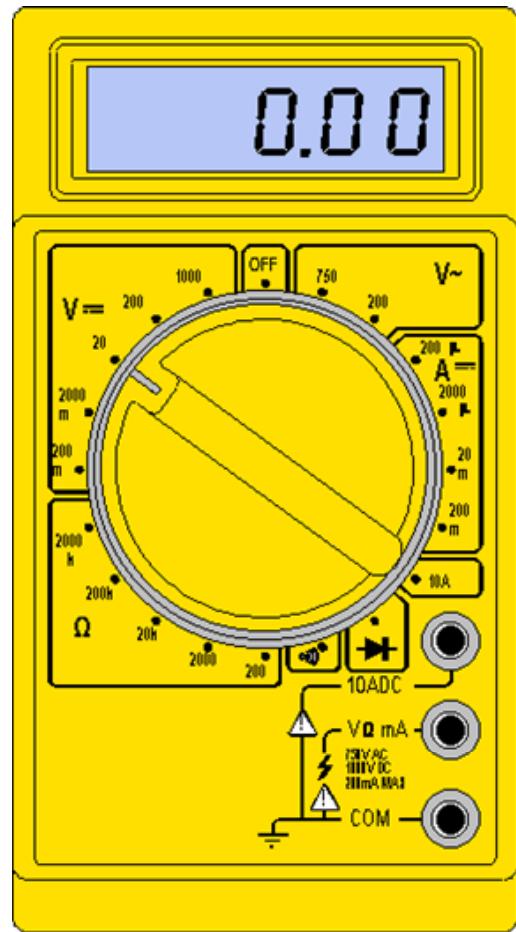
- DMM is a measuring instrument
- An **ammeter** measures current
- A **voltmeter** measures the potential difference (voltage) between two points
- An **ohmmeter** measures resistance
- A **multimeter** combines these functions, and possibly some additional ones as well, into a single instrument

# Digital Multimeter 2

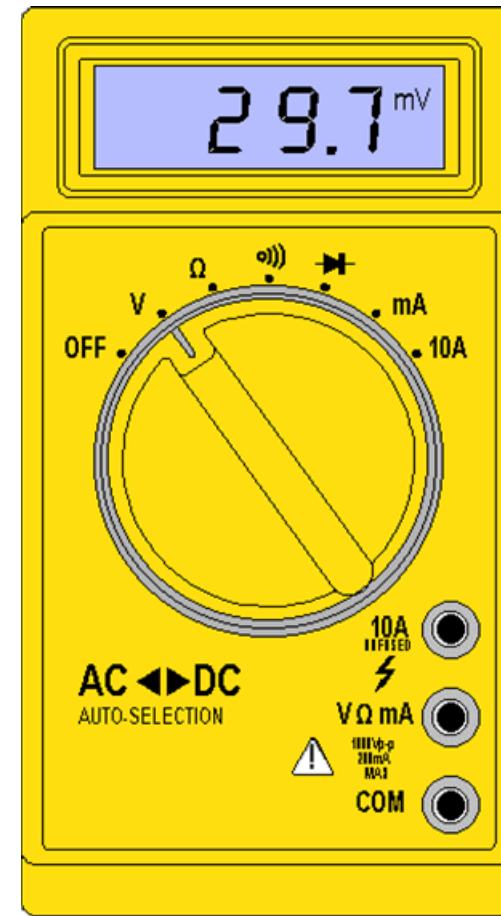


- Voltmeter
  - Parallel connection
- Ammeter
  - Series connection
- Ohmmeter
  - Without any power supplied
- Adjust range (start from highest limit if you don't know)

# Digital Multimeter 3

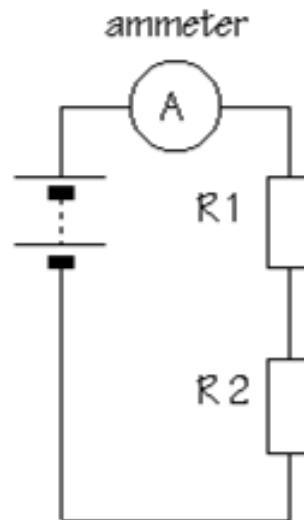
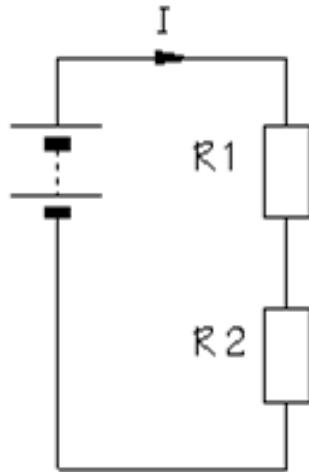


Switched Ranging DMM



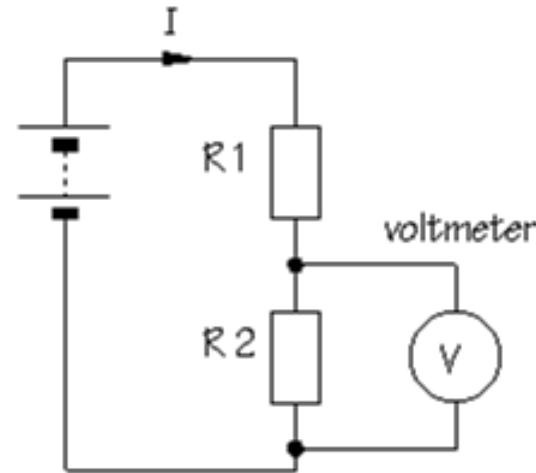
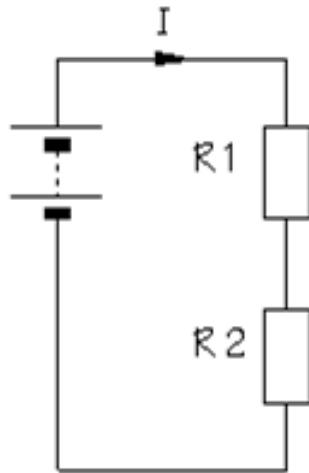
Auto Ranging DMM

# Ammeter Connection



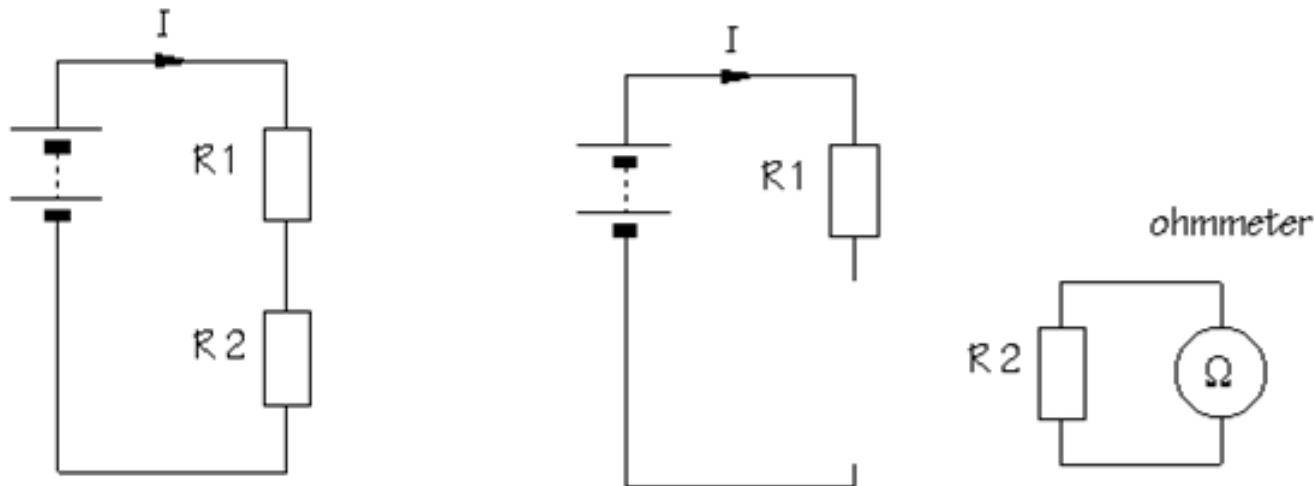
- Break the circuit so that the ammeter can be connected in series
- All the current flowing in the circuit must pass through the ammeter
- An ammeter must have a very **LOW** input impedance

# Voltmeter Connection



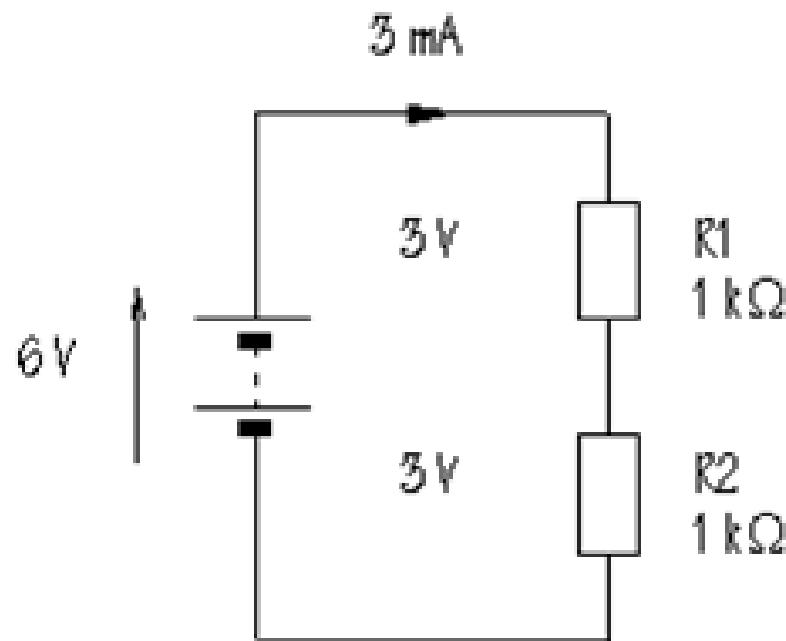
- The voltmeter is connected in parallel between two points of circuit
- A voltmeter should have a very **HIGH** input impedance

# Ohmmeter Connection



- An ohmmeter does not function with a circuit connected to a power supply
- Must take it out of the circuit altogether and test it separately

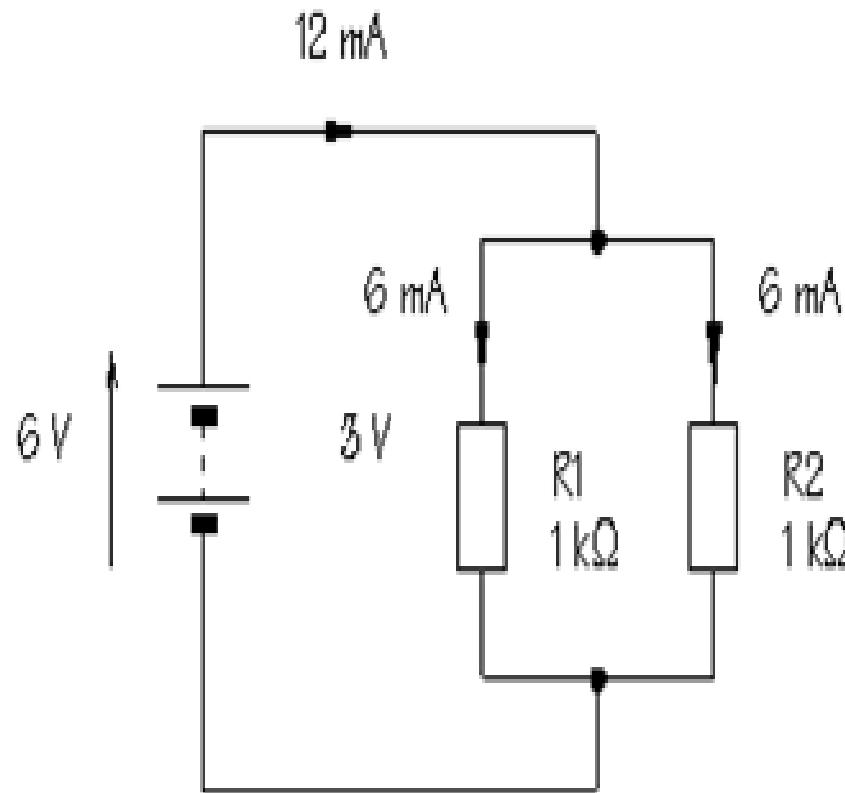
# Resistors in Series



$$R_{\text{total}} = R_1 + R_2$$

$$R_{\text{total}} = 1 + 1 = 2 \text{ k}\Omega$$

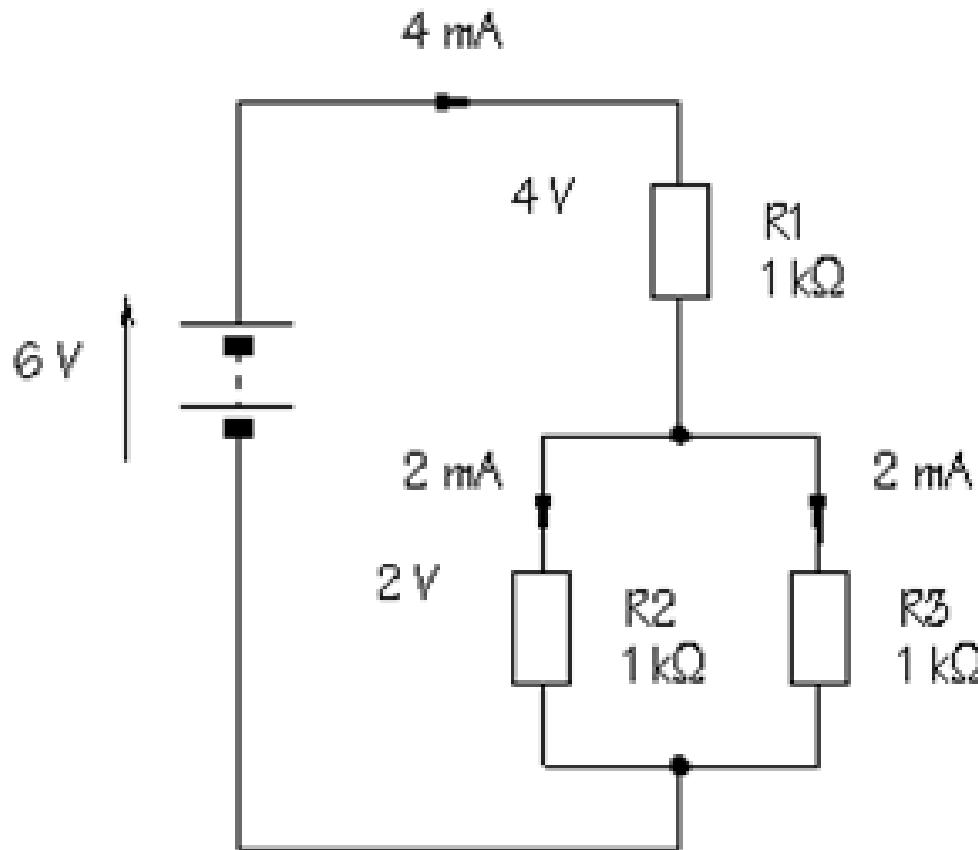
# Resistors in Parallel



$$R_{total} = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_{total} = \frac{1 \times 1}{1 + 1} = \frac{1}{2} = 0.5\text{k}\Omega$$

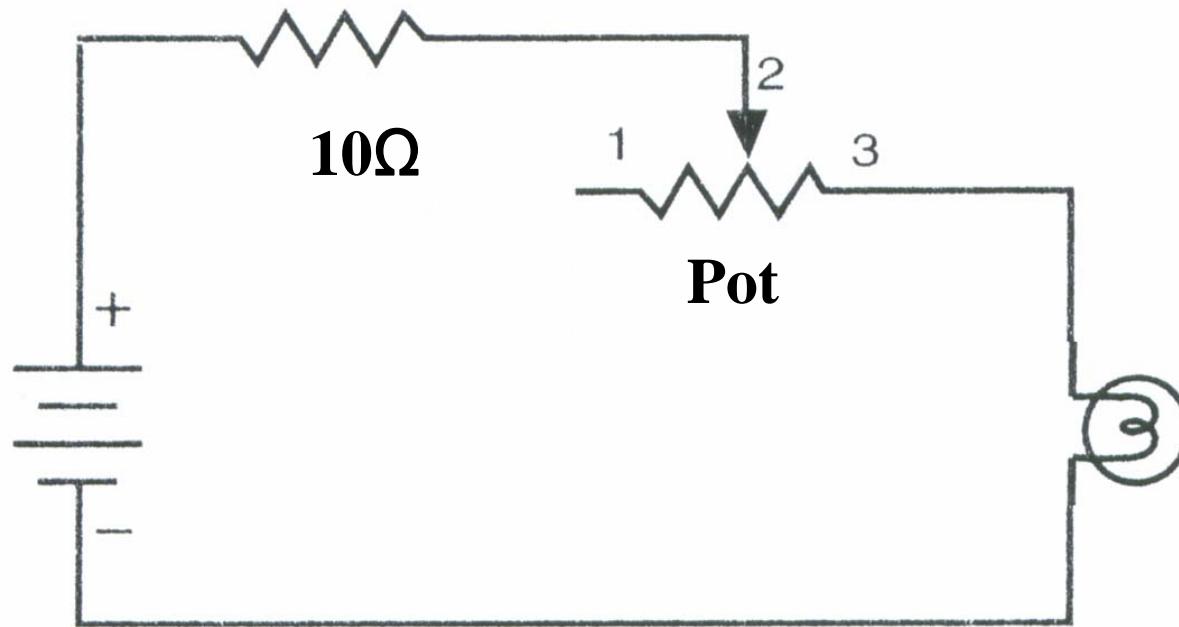
# Exercise 1



$$R_{total} = R_1 + \frac{R_2 \times R_3}{R_2 + R_3}$$

$$R_{total} = 1 + \frac{1 \times 1}{1 + 1} = \frac{3}{2} = 1.5 k\Omega$$

# Exercise 2

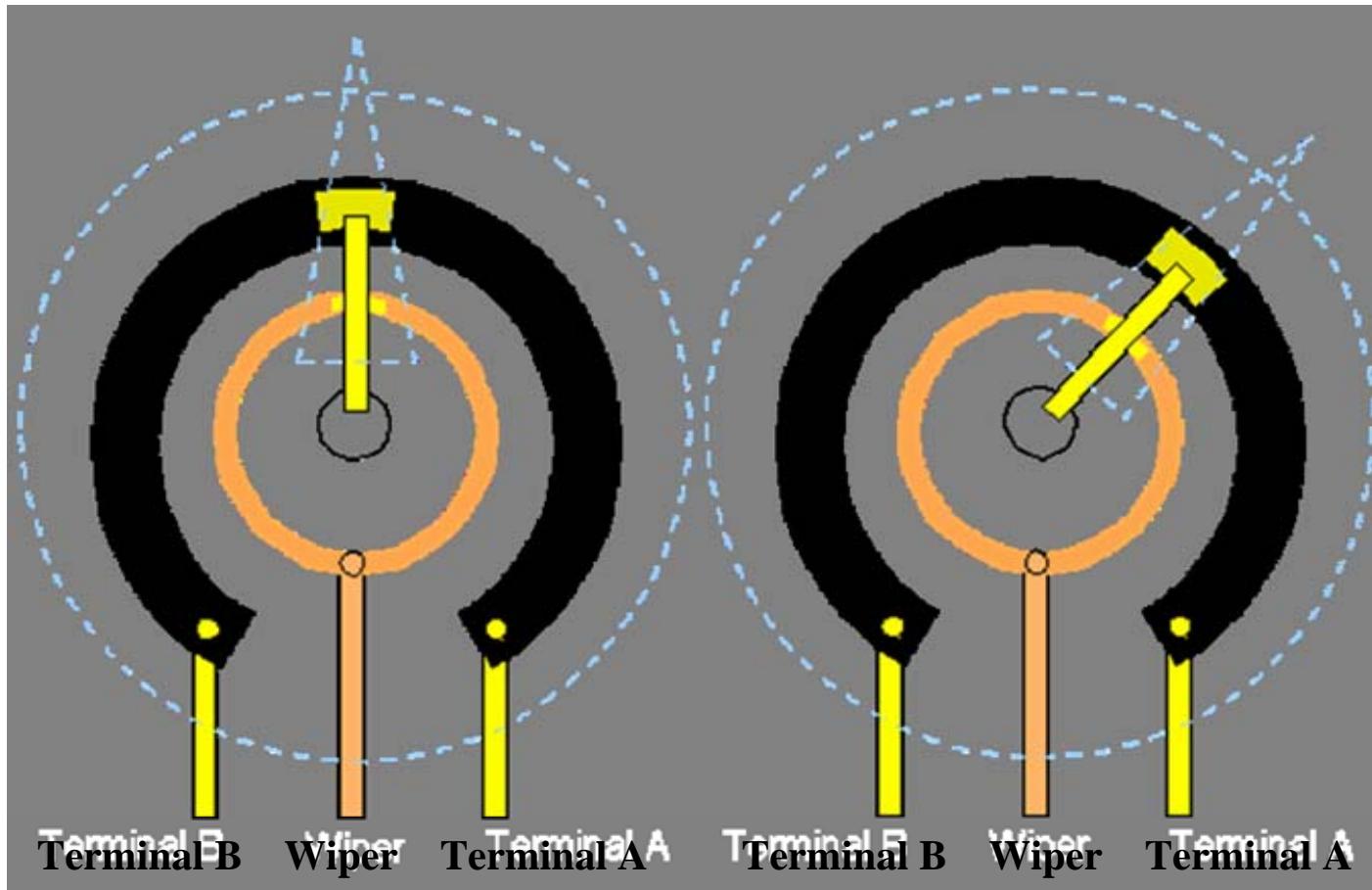


# Potentiometer 1

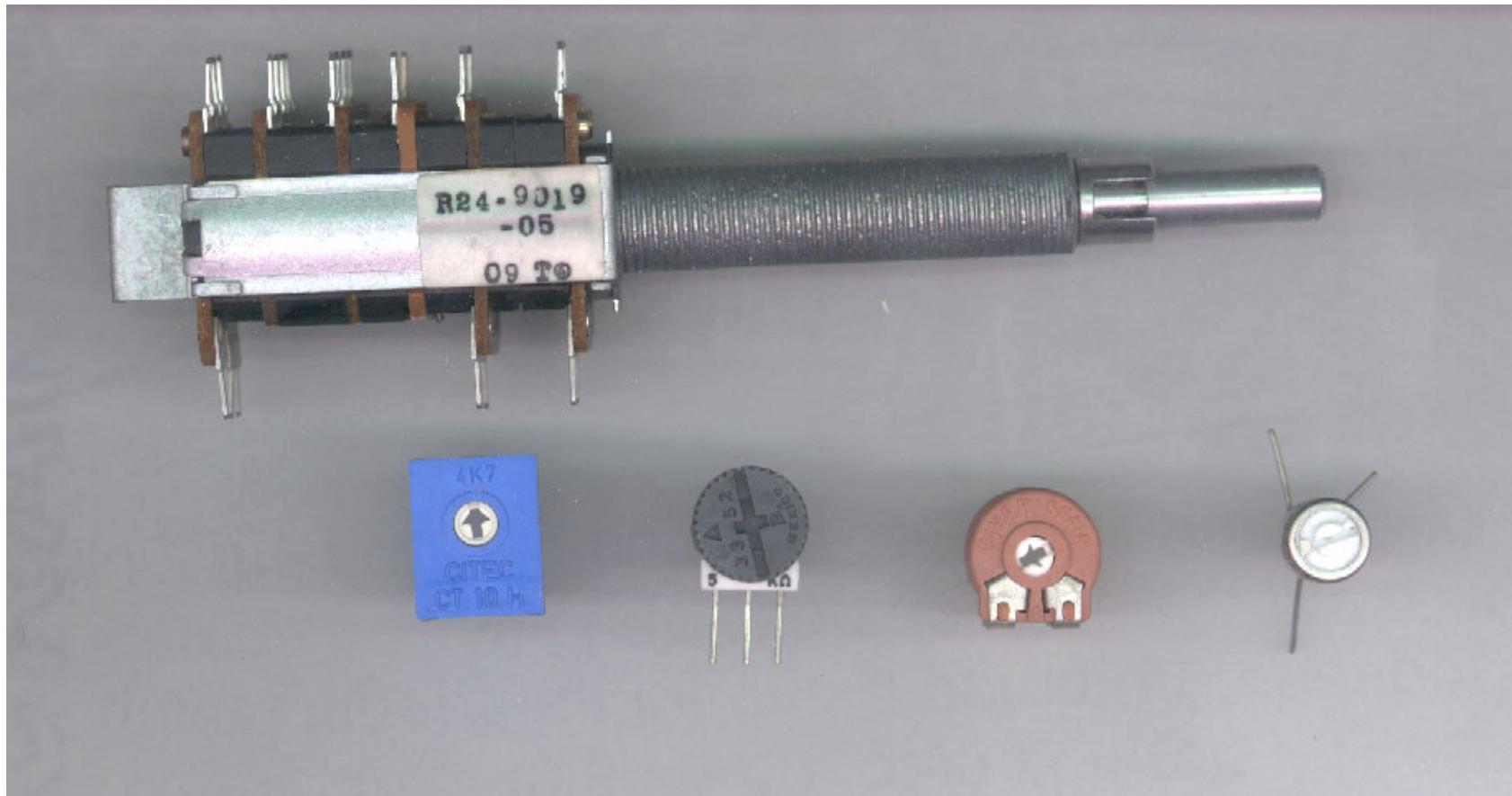


- Has an adjustable resistance
- Rotary potentiometer
- Linear potentiometer
- Use as a position sensor

# Potentiometer 2



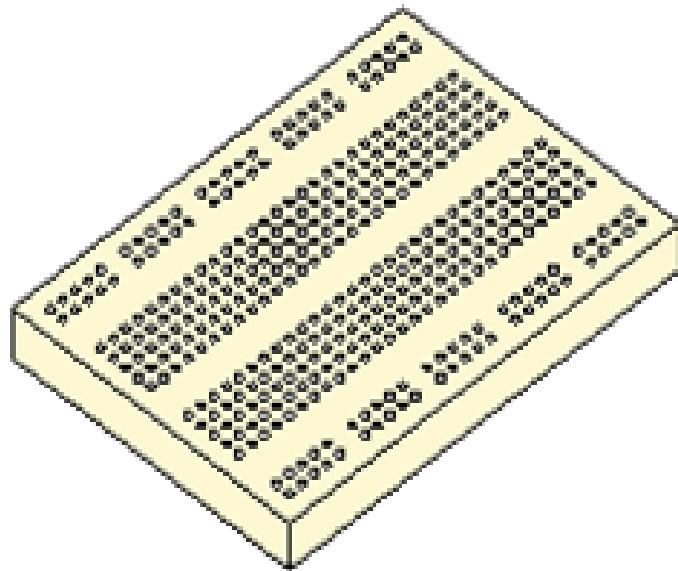
# Rotary Potentiometers



# Linear Potentiometer

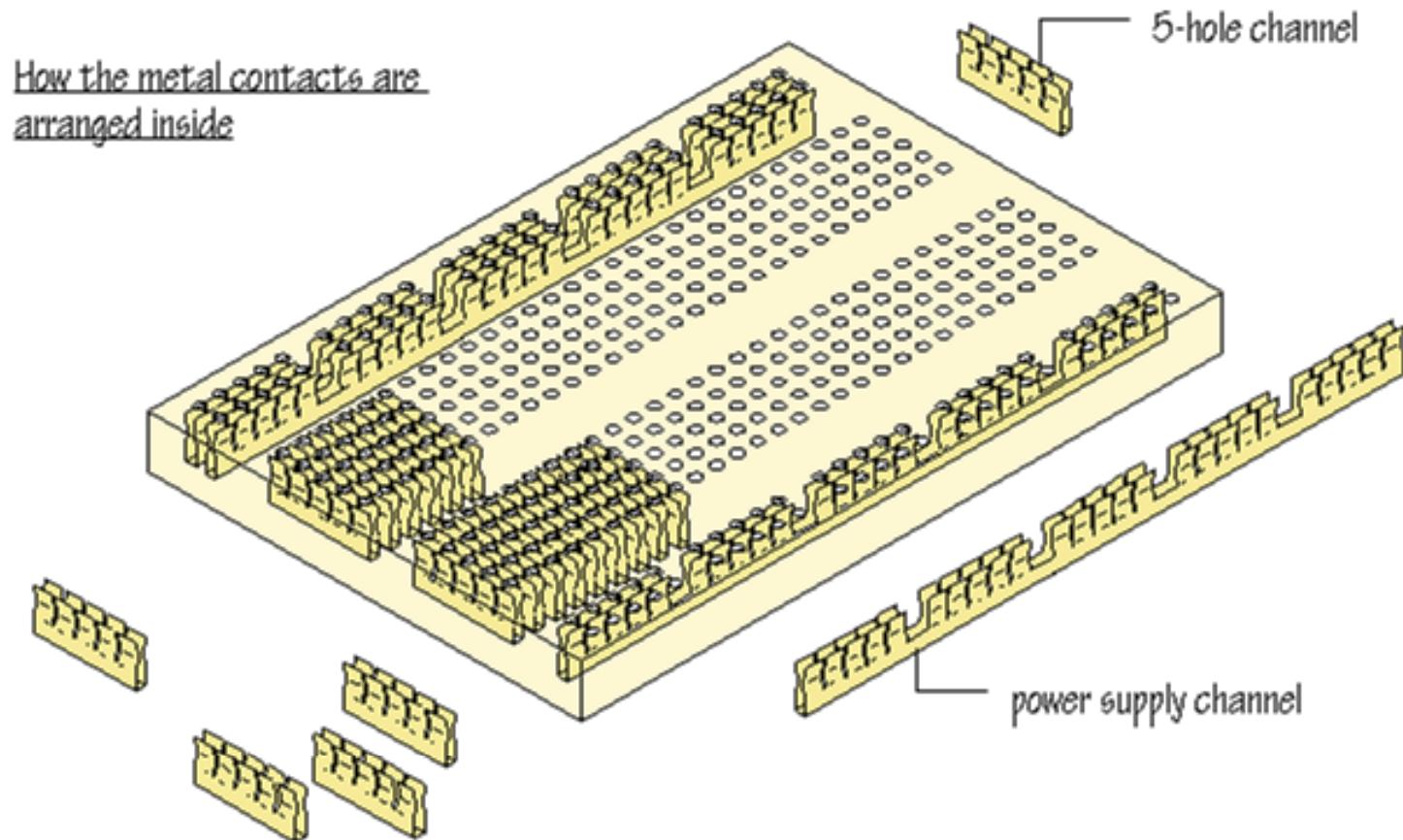


# Breadboard 1

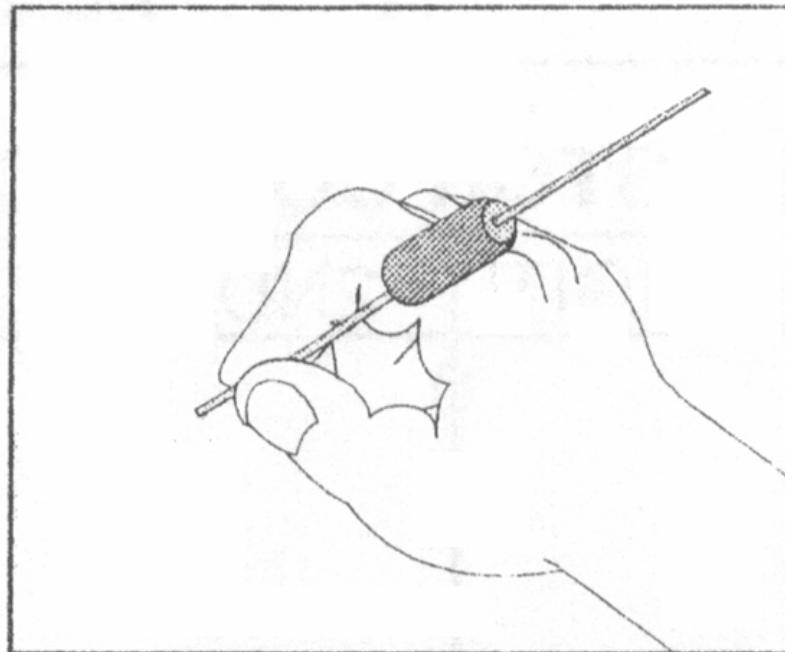


Prototype board is used for building temporary circuits, without soldering. Component leads are pushed into the holes in the board to make connections.

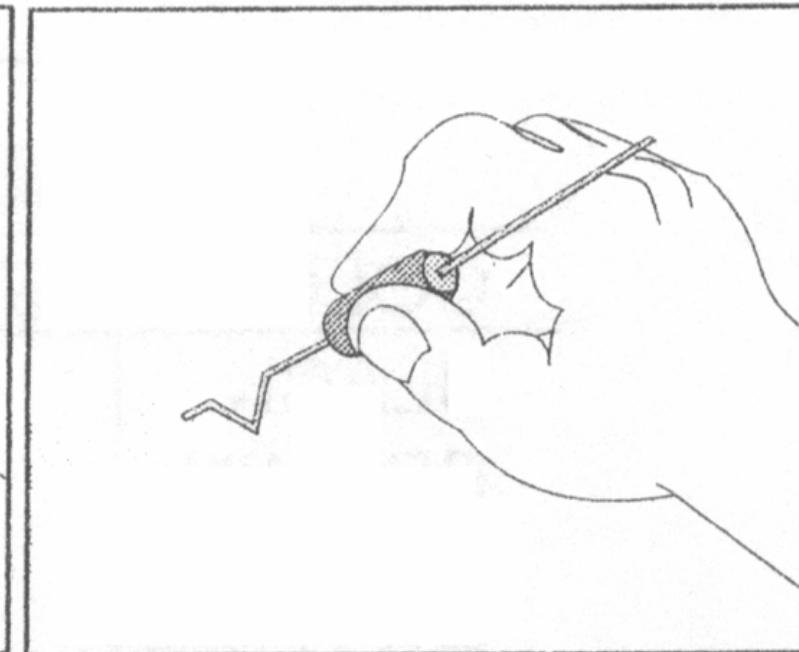
# Breadboard 2



# How to Insert a Component into a Breadboard



RIGHT



WRONG

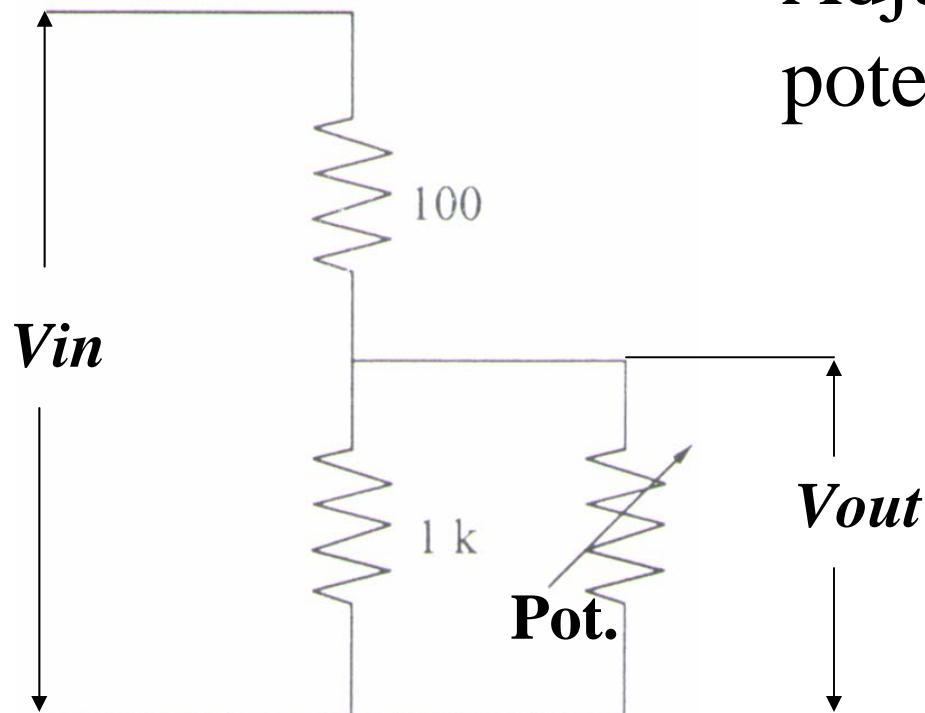
# Resistor Experiments

Experiments	Chapters
What's micro controller	
Basic A and D	
Earth measurements	
Robotics	
StampWorks	
Others	On coming slides

# Experiment Details 1

- 1. Read resistors' nominal values using color code**
- 2. Determine resistors' values using an Ohmmeter**
- 3. Determine resistors' values using DMM (Voltmeter and Ammeter) and compare with results from 1 and 2**
- 4. Make serial connection with two resistors**
  - 1) Repeat 1, 2, and 3**
- 5. Make parallel connection with two resistors**
  - 1) Repeat 1, 2, and 3**
- 6. Make combination of serial and parallel connection with three resistors**
  - 1) Repeat 1, 2, and 3**

# Experiment Details 2



- Adjust and Determine the potentiometer value such that

$$V_{out} = \frac{5}{6}V_{in}$$

# Lecture 2

Mechatronics

# Mechatronics 1

- Synergistic integration of
  - Mechanical engineering
  - Control theory
  - Computer science
  - Electronics
- To manage complexity, uncertainty, and communication in engineered systems

# Mechatronics 2

- Typical knowledgebase for optimal design and operation of mechatronic systems comprises of
  - Dynamic system modeling and analysis
  - Decision and control theory
  - Sensors and signal conditioning
  - Actuators and power electronics
  - Hardware interfacing
  - Rapid control prototyping
  - Embedded computing

# Mechatronic Applications

- **Smart consumer products:** home security, camera, microwave oven, toaster, dish washer, laundry washer-dryer, climate control units, etc.
- **Medical:** implant-devices, assisted surgery, haptic, etc.
- **Defense:** unmanned air, ground, and underwater vehicles, smart munitions, jet engines, etc.
- **Manufacturing:** robotics, machines, processes, etc.
- **Automotive:** climate control, antilock brake, active suspension, cruise control, air bags, engine management, safety, etc.
- **Network-centric, distributed systems:** distributed robotics, tele-robotics, intelligent highways, etc.

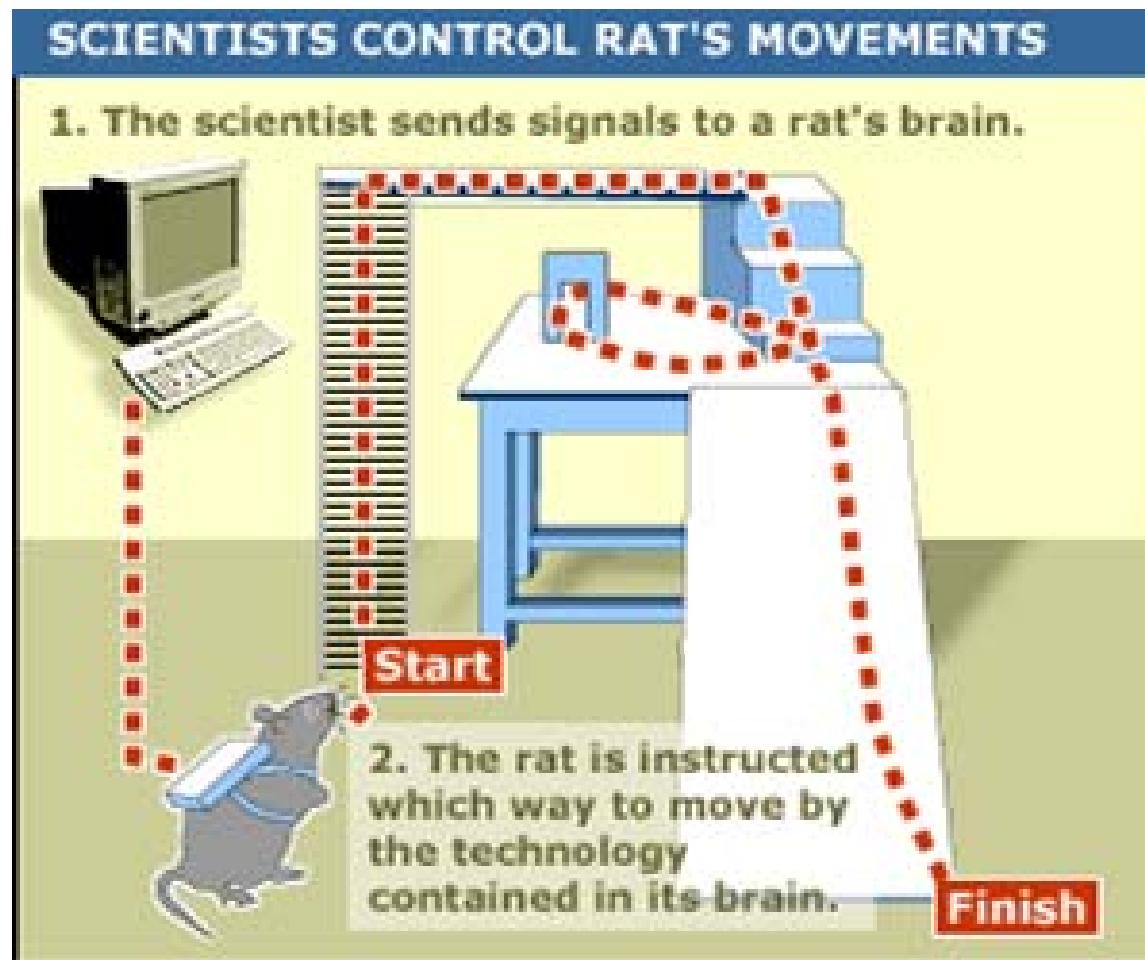
# Roborat 1



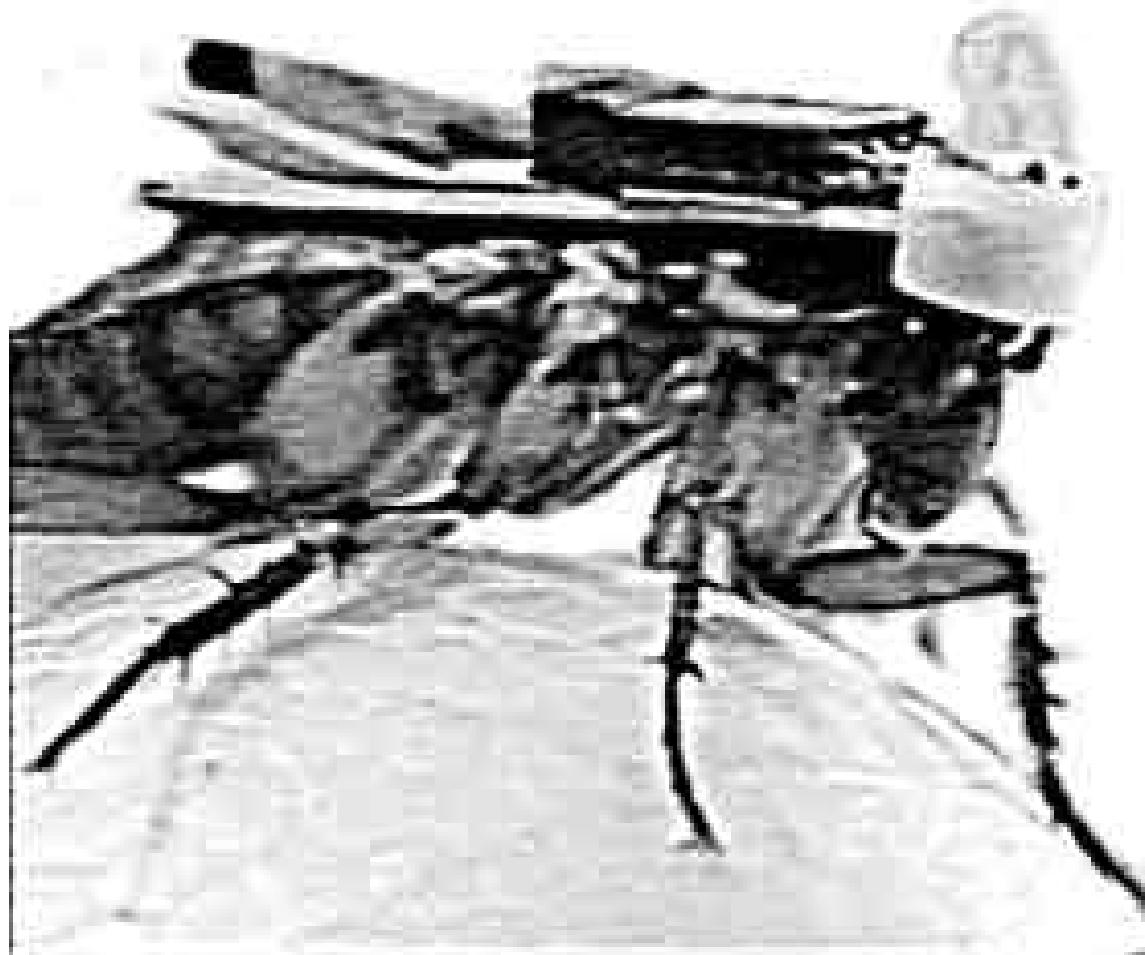
# Roborat 2



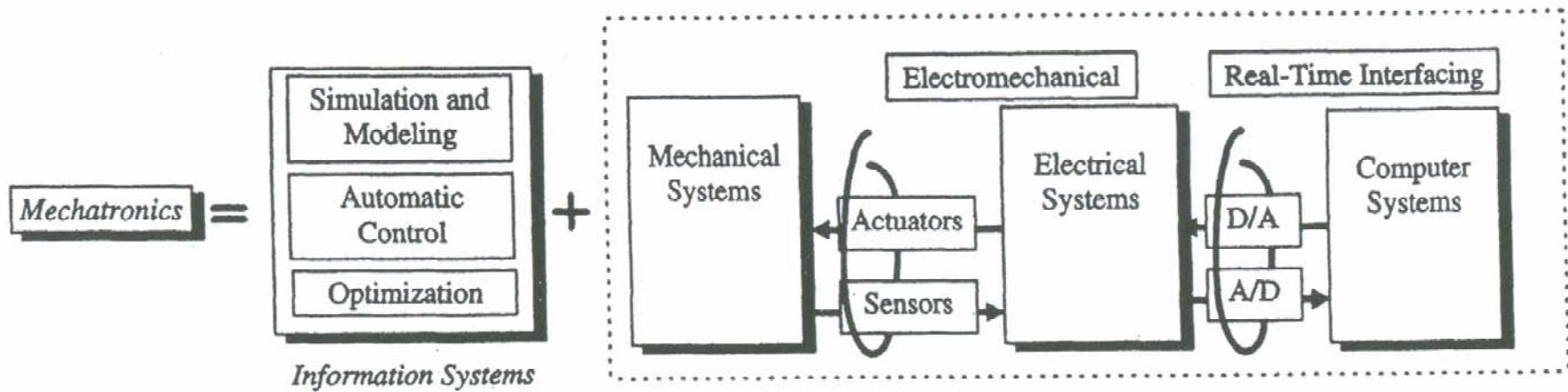
# Roborat 3



# Robocockroach



# Key Elements of Mechatronics



# Elements of Mechatronics 1

- Mechanical elements



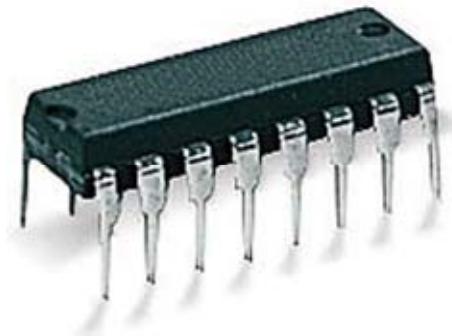
# Elements of Mechatronics 2

- Electromechanical elements



# Elements of Mechatronics 3

- Electrical/Electronic elements



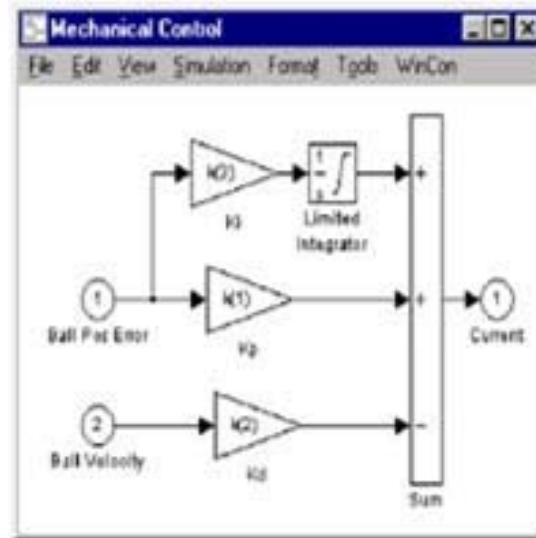
# Elements of Mechatronics 4

- Control interface/computing hardware elements



# Elements of Mechatronics 4

- Computer elements



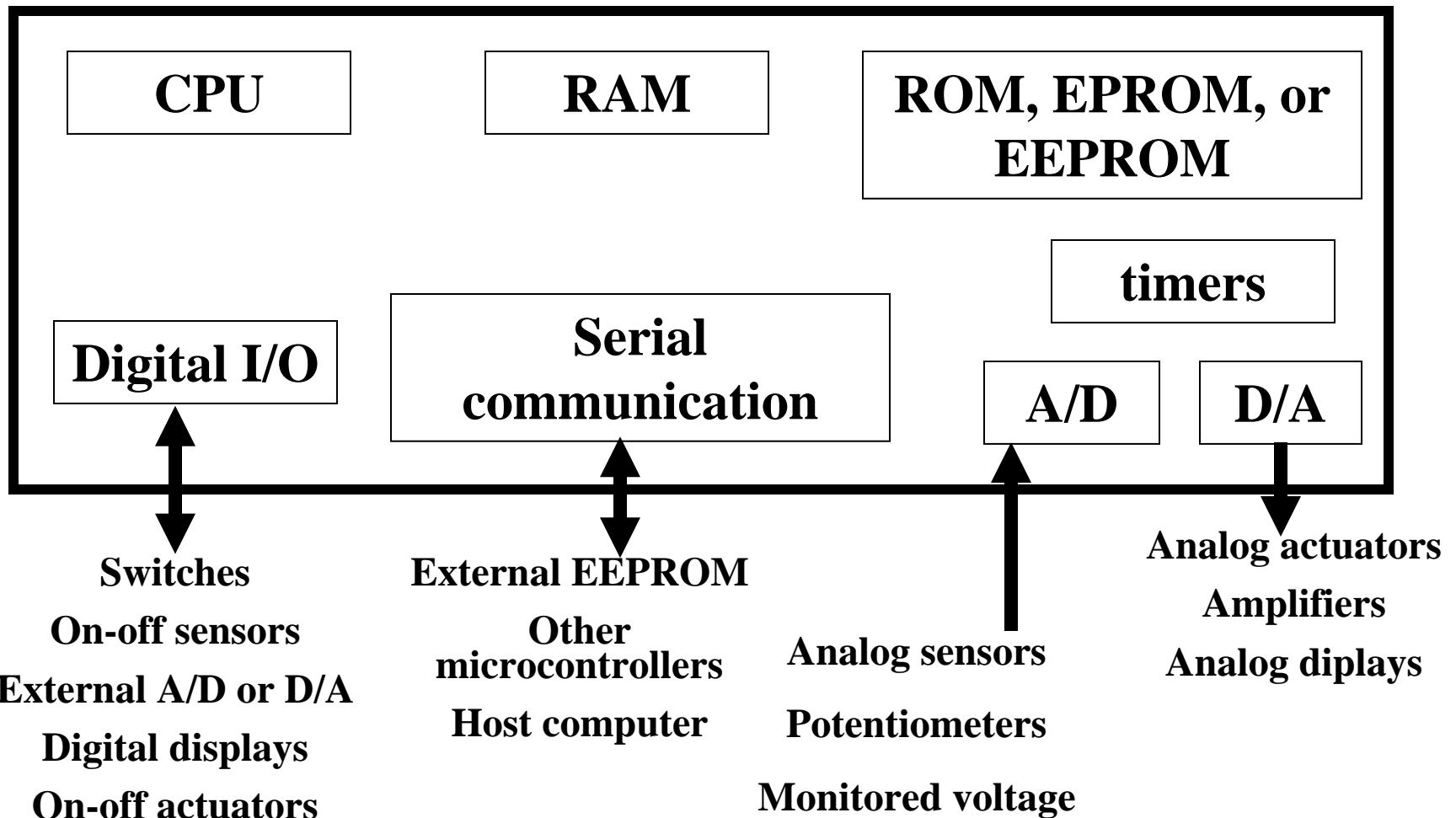
# Microprocessors

- Perform arithmetic, logic, communication, and control function
- Arithmetic/logic unit(ALU)
- Instruction registers and decoders
- Data registers
- Control unit
- Intel 4004 (4bit microprocessor),  
Intel 8080 (8bit microprocessor)

# Microcontrollers

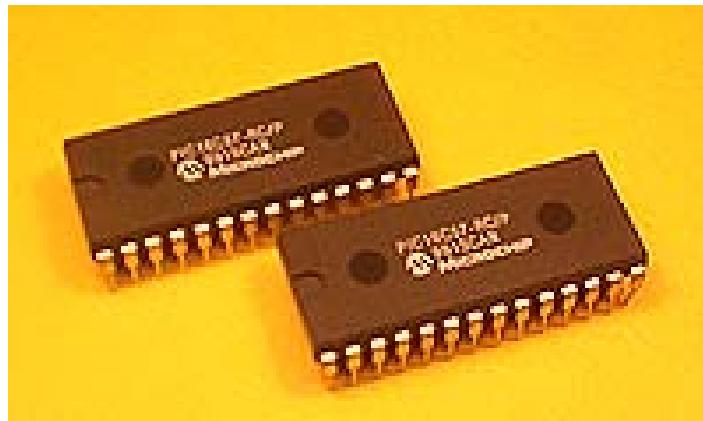
- Special purpose miniaturized computers
- Single integrated circuit containing many specialized and sophisticated circuits and functions
- Two primary components
  - RAM
  - CPU with instruction set

# Microcontroller Architecture

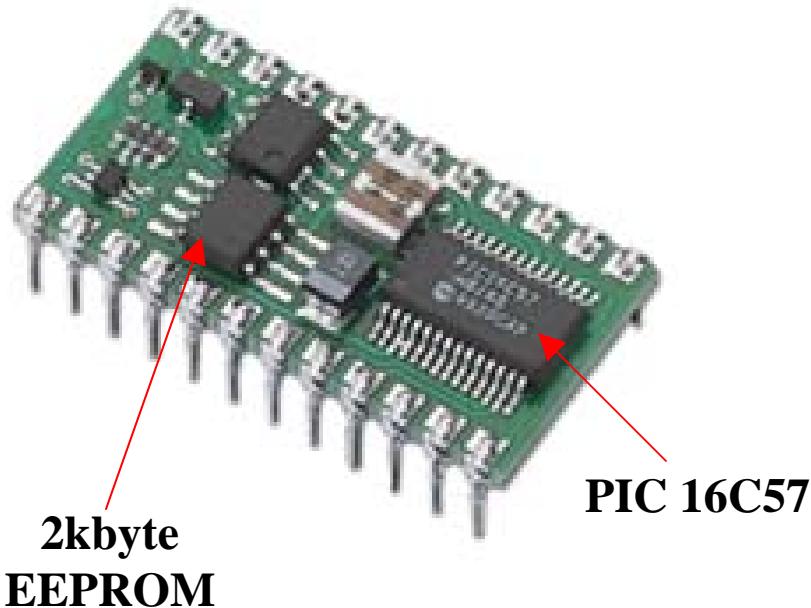


# PIC Microcontrollers

- PIC 16C57 (unit price: \$7.50 in single quantities, \$3.50 in quantities of 1000 or more)



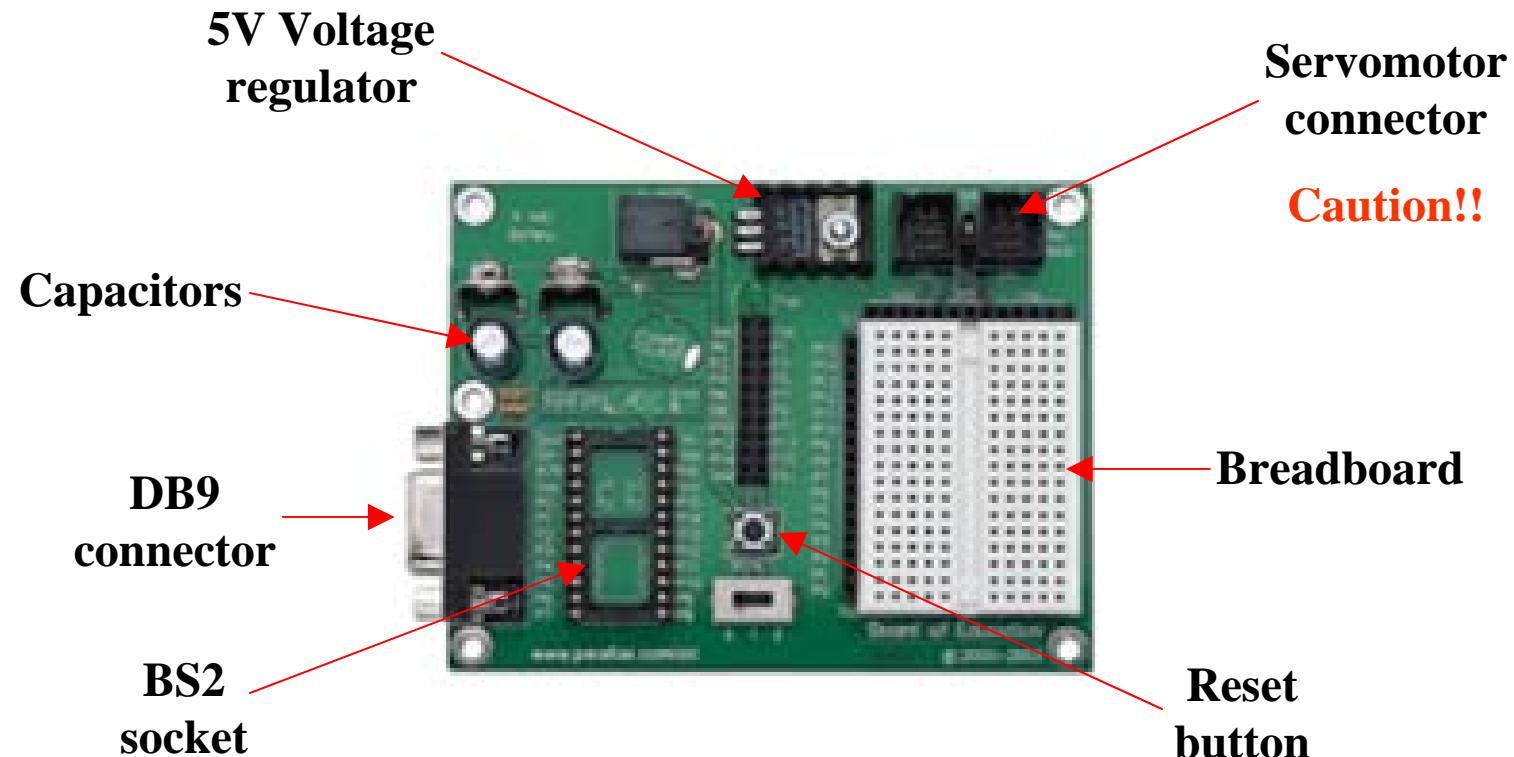
# Basic Stamp 2



- Simple and easy to use
- PIC-based PBASIC interpreter on ROM
- 16 digital I/O

[http://www.parallax.com/Downloads/Documentation/bs/mod/BASIC\\_Stamp\\_2\\_Schematic\\_Rev\\_F.pdf](http://www.parallax.com/Downloads/Documentation/bs/mod/BASIC_Stamp_2_Schematic_Rev_F.pdf)

# Stamp Development Board

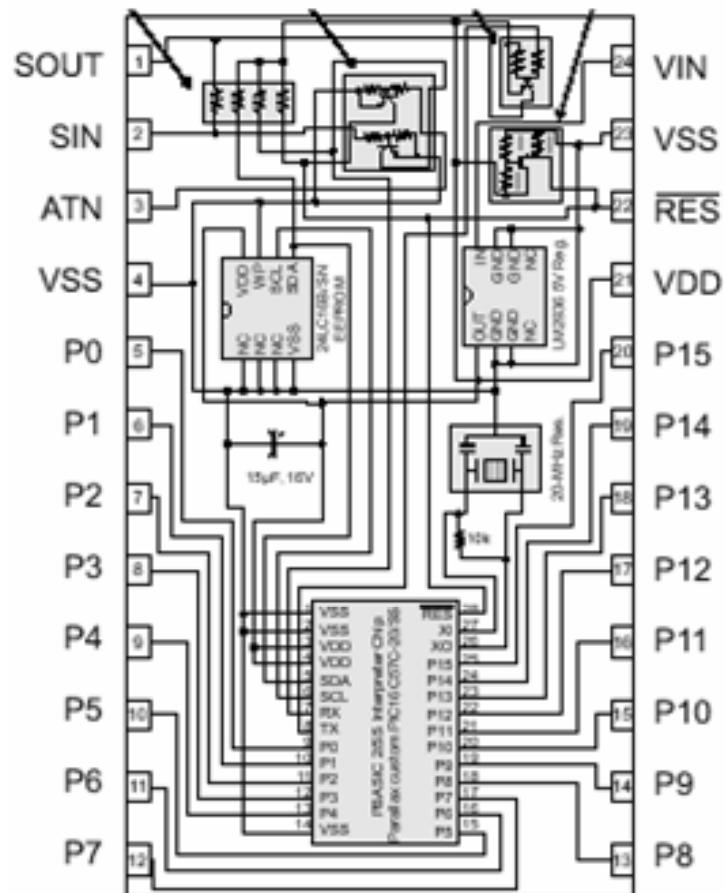


Board of education

# Hardware Considerations

- Power requirements
  - BS2 requires regulated 5DCV and draws about 8mA
- Each I/O pin of BS2 can
  - Source up to **20mA**
  - Sink up to **25 mA**
- When the voltage regulator on BOE is being used, all I/O pin as a group can
  - Source up to **40mA**
  - Sink up to **50mA**

# BS2 Pin Descriptions



Pin	Name	Description
1	SOUT	Serial out
2	SIN	Serial in
3	ATN	Attention
4	VSS	System ground
5-20	P0-P15	Input/Output pins
21	VDD	5DC V
22	RES	Reset
23	VSS	System ground
24	VIN	Unregulated power in

# BS2 Variable Types

Var type	Size	Range of value
bit	1 bit	0, 1
nib	4 bits	0-15
byte	8 bits	0-255
word	16 bits	0-65535

**OnOff var bit**

**InOutPins var nib**

**ADCin var byte**

**Count var word**

# Binary, Decimal, and Hexadecimal Numbers

Binary	Decimal	Hexadecimal
0000	0	0
0001	1	1
0010	2	2
0011	3	3
0100	4	4
0101	5	5
0110	6	6
0111	7	7

Binary	Decimal	Hexadecimal
1000	8	8
1001	9	9
1010	10	A
1011	11	B
1100	12	C
1101	13	D
1110	14	E
1111	15	F

# Variable Command

b0=10

b0= %00001010

b0=\$0A

$(375)_2$  is 00000001 01110111

b3 var byte

b3=375

Debug DEC b3

$$01110111 = 2^7(0) + 2^6(1) + 2^5(1) + 2^4(1)$$

$$+ 2^3(0) + 2^2(1) + 2^1(1) + 2^0(1)$$

$$= 119$$

**Result is 119**

# Assigning Pins for I/O

**DIRS: 1 for output, 0 for input**

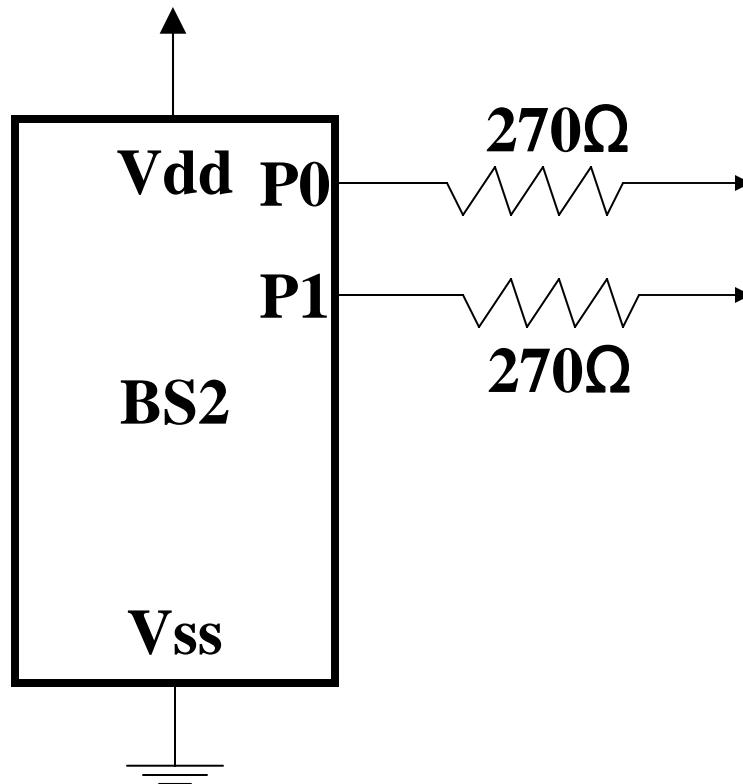
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DIR D				DIR C				DIR B				DIR A			
DIR H								DIR L							

**OUTS**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
OUT D				OUT C				OUT B				OUT A			
OUT H								OUT L							

**Same as for INS**

# How to Protect the I/O Pins



$$I = \frac{5}{270} \approx 19mA$$

# Variables Experiments

Experiments	Chapters
What's micro controller	
Basic A and D	
Earth measurements	
Robotics	
StampWorks	
Others	On coming slides

# Experiment Details 1

**myCon** CON 10

**myVar1**=5

**myVar1** VAR Byte

**myVar2**=25

**myVar2** VAR Byte

**myVar3**=375

**myVar3** VAR word

**myVar4**=400

**myVar4** VAR word

# Experiment Details 2

**debug "myCon= ", DEC myCon, cr**

**debug "myVar1= ", DEC myVar1, cr**

**debug "myVar2= ", DEC myVar2, cr**

**debug "myVar3= ", DEC myVar3, cr**

**debug "myVar4= ", DEC myVar4, cr**

**debug "myVar3 in BIN= ", BIN myVar3, cr**

**debug "Low byte of 375=", BIN myVar3.byte0, cr**

**debug "High byte of 375=", BIN myVar3.byte1, cr**

# Experiment Details 3

**b0=10**

**debug "b0 input in DEC.", cr**

**debug "b0 in DEC= ", DEC b0, cr**

**debug "b0 in BIN= ", BIN b0, cr**

**debug "b0 in HEX= ", HEX b0, cr**

# Experiment Details 4

**b0=%00001010**

**debug "b0 input in BIN.", cr**

**debug "b0 in DEC= ", DEC b0, cr**

**debug "b0 in BIN= ", BIN b0, cr**

**debug "b0 in HEX= ", HEX b0, cr**

# Experiment Details 5

**b0=\$0A**

**debug "b0 input in HEX.", cr**

**debug "b0 in DEC= ", DEC b0, cr**

**debug "b0 in BIN= ", BIN b0, cr**

**debug "b0 in HEX= ", HEX b0, cr**

# Experiment Details 6

**b0=10**

**b1=20**

**b2=b0+b1**

**b3=375**

**debug "b0 in DEC= ", DEC b0, cr**

**debug "b1 in DEC= ", DEC b1, cr**

**debug "b2 in DEC= ", DEC b2, cr**

**debug "b3 in DEC= ", DEC b3, cr**

# Experiment Details 7

**debug "b0 in BIN= ", BIN b0, cr**

**debug "b1 in BIN= ", BIN b1, cr**

**debug "b2 in BIN= ", BIN b2, cr**

**debug "b3 in BIN= ", BIN b3, cr**

# Experiment Details 8

w2=375

**debug "w2 in DEC= ", DEC w2, cr**

**debug "w2 in BIN= ", BIN w2, cr**

**debug "b4 in BIN= ", BIN b4, cr**

**debug "b5 in BIN= ", BIN b5, cr**

# Experiment Details 9

- Please read “**BASIC Stamp Frequently Asked Questions** ”
- Please read and run all programs on “**BASIC Stamp User's Manual** ” from page 1 to page 75
- And **DEBUG** on page 97