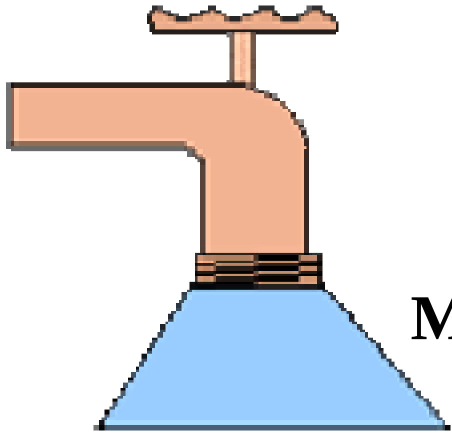
Lecture 1

Resistor

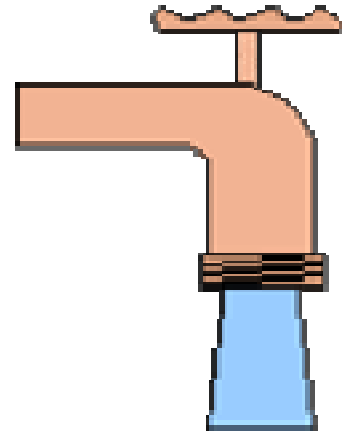
What is Current?

- 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 **milliamps**, **mA**
- Like water flow

Water Analogy



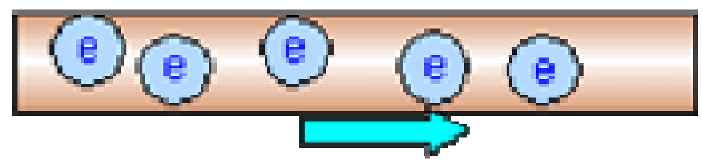
More current



Less current

More current

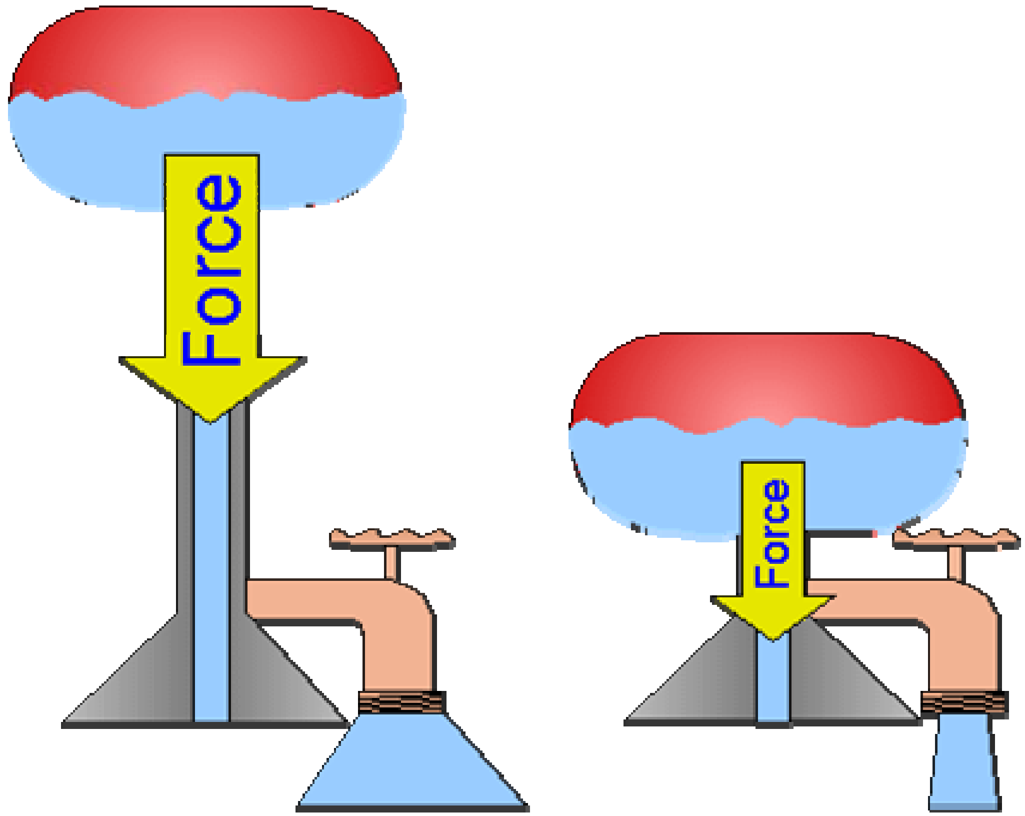
Less current



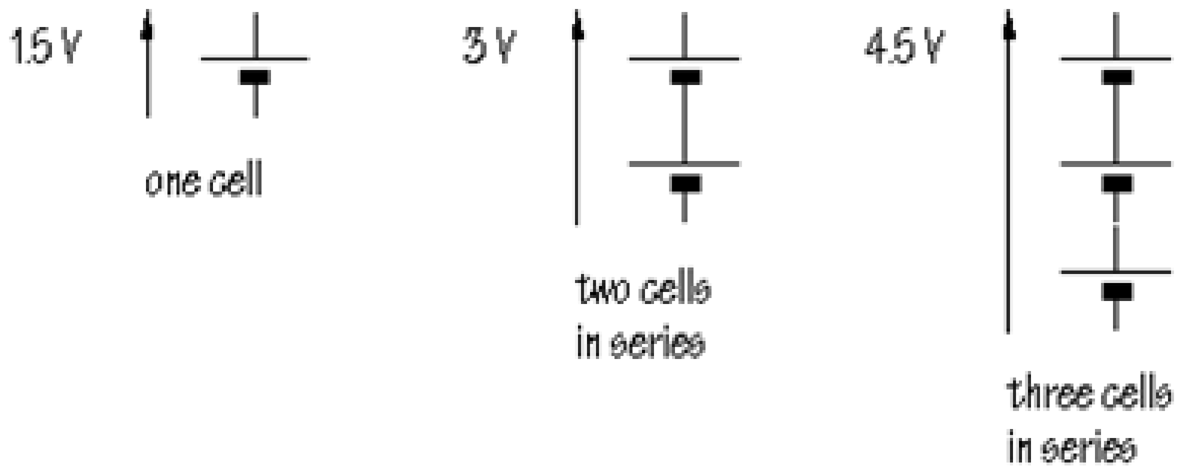
What is Voltage?

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

Water Analogy

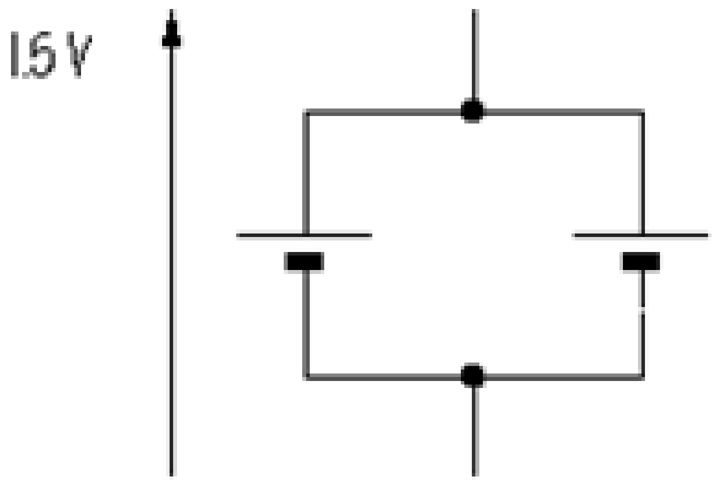


Series Connection of Cells



- 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

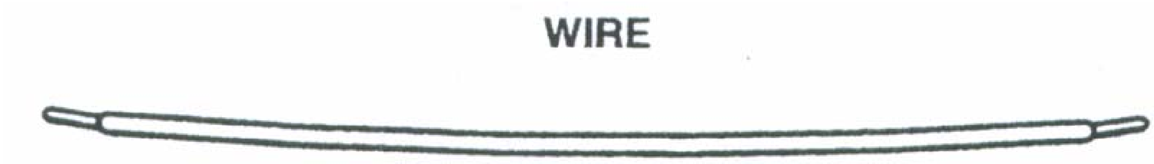
- A cell provides a steady voltage, so that current flow is always in the same direction
  - This is called **direct current**, or **d.c**
- The domestic mains provides a constantly changing voltage which reverses in polarity 60 times every second
  - This gives rise to **alternating current**, or **a.c**

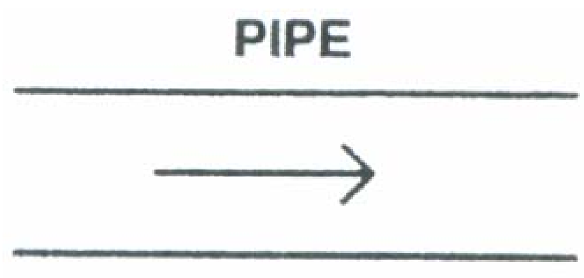
Power Supply

Digital

Analog

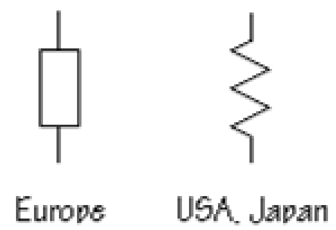
Water Analogy of Wires



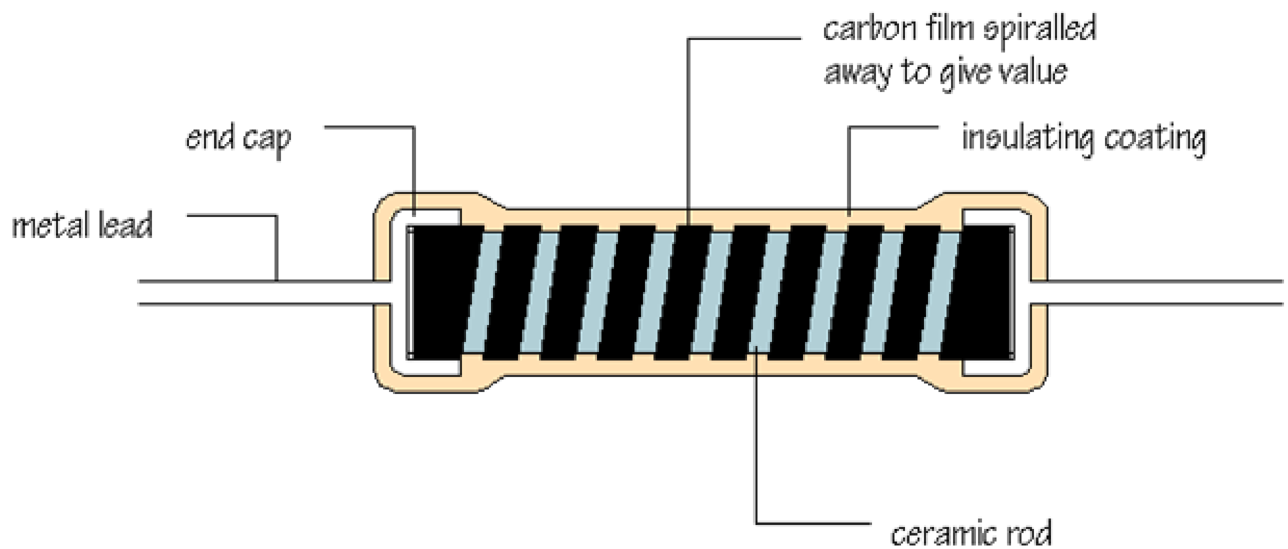


Resistors

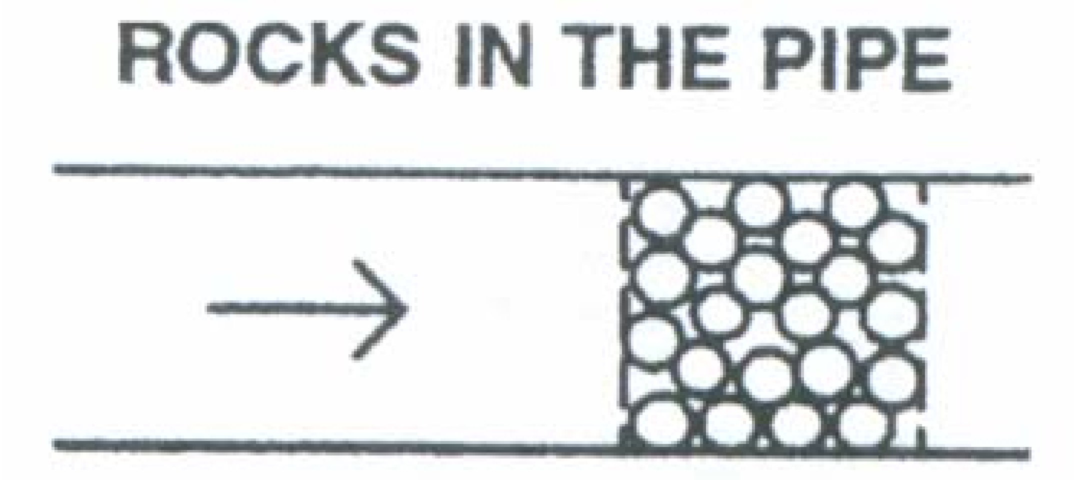
- Dissipative elements that convert electrical energy into heat
- Resistors limit current
- Unit is **ohms**, Ω



Resistor Symbols



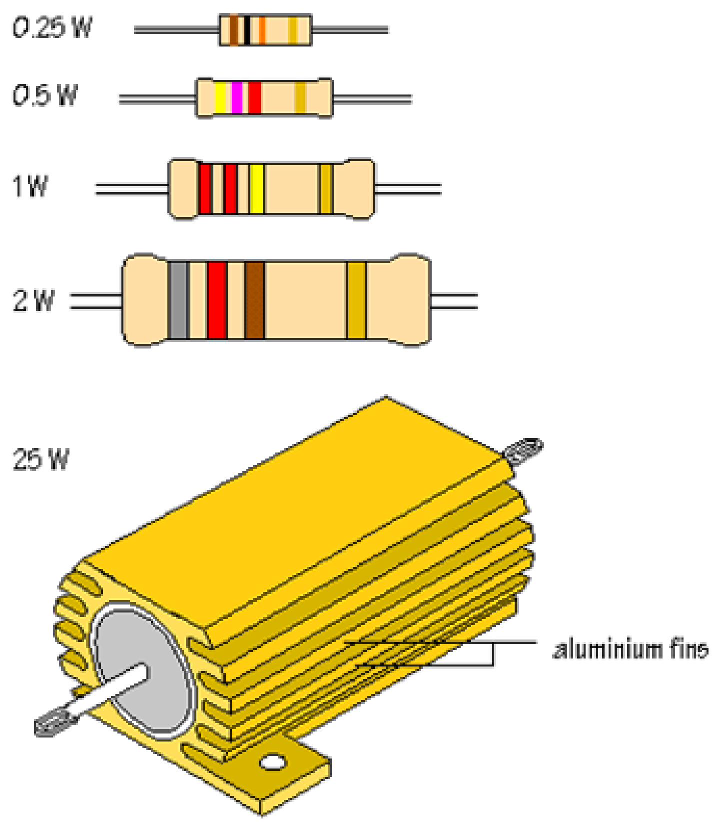
Water Analogy of Resistor

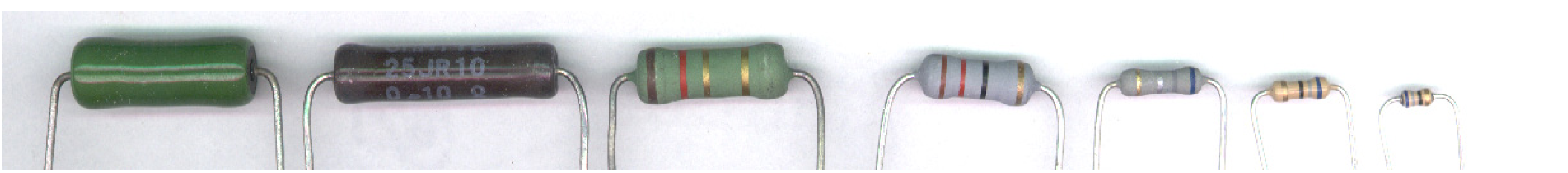


Resistor Applications

- 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



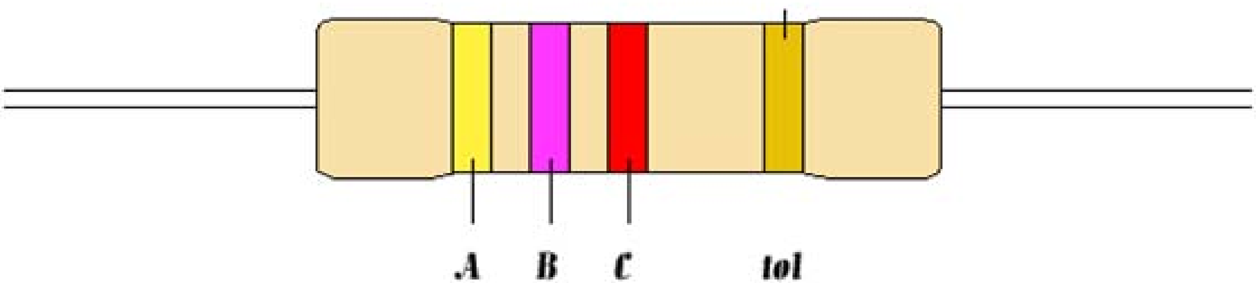


How to Read Resistor Values 1

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

How to Read Resistor Values 2

By color code



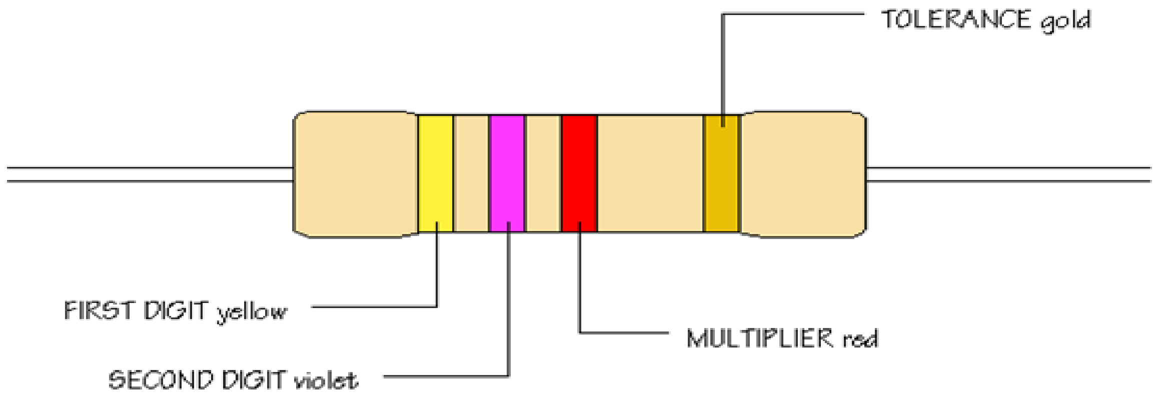
$$\text{Resistor value} = AB \times 10^{C} \pm tol\%(\Omega)$$

Resistance Color Code

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

Tolerance	*Color*
$\pm 1\%$	brown
$\pm 2\%$	red
$\pm 5\%$	gold
$\pm 10\%$	silver

Example

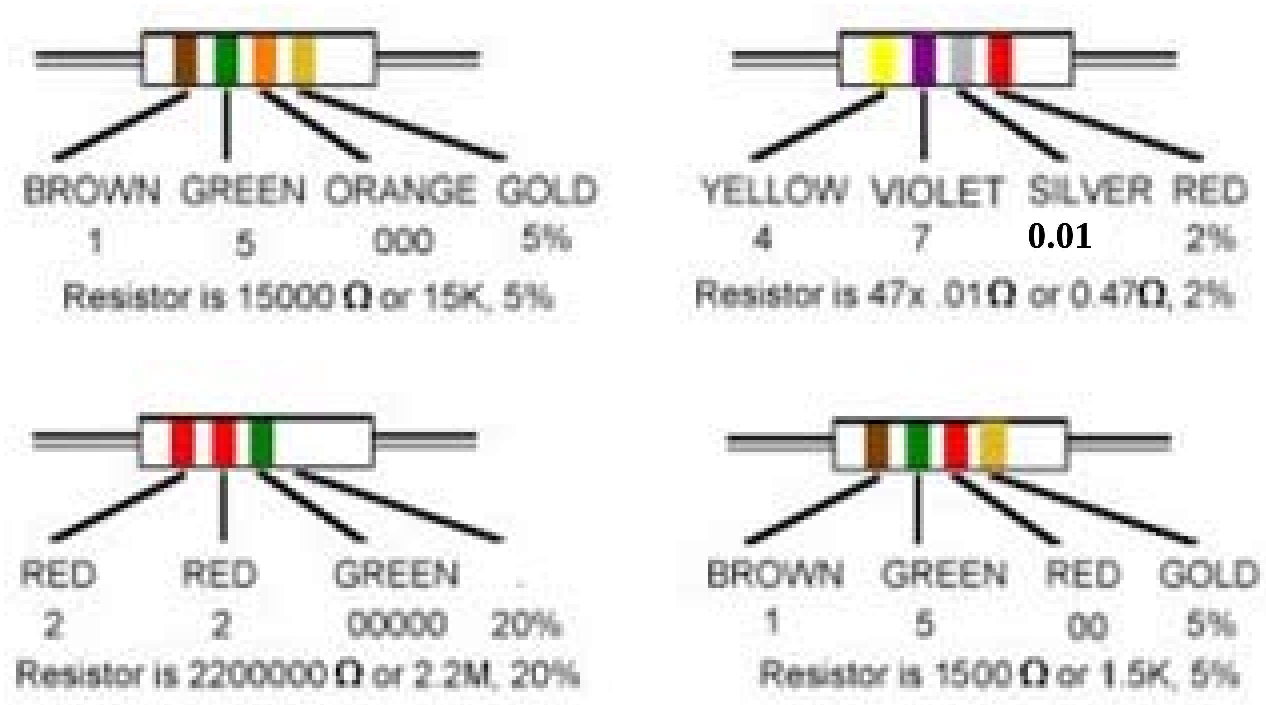


- The first band is yellow, so the first digit is 4
- The second band is violet, so the second digit is 7
- The third band is red, so the multiplier is 10^2
- Resistor value is $47 \times 10^2 \pm 5\% (\Omega)$

Metric Units and Conversions

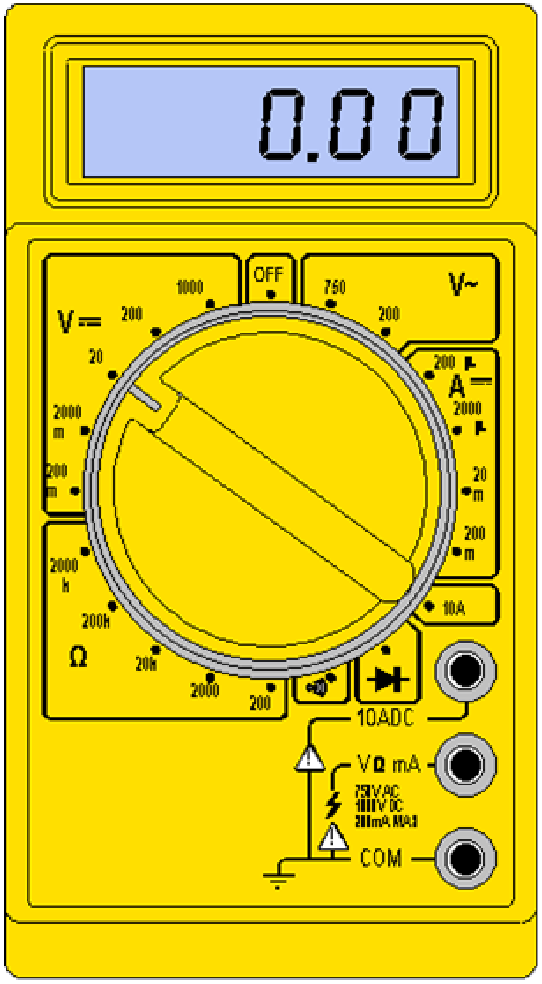
Abbreviation	Means	Multiply unit by	Or
p	pico	.000000000001	10^{-12}
n	nano	.000000001	10^{-9}
µ	micro	.000001	10^{-6}
m	milli	.001	10^{-3}
.	Unit	1	10^{0}
k	kilo	1,000	10^{3}
M	mega	1,000,000	10^{6}
G	giga	1,000,000,000	10^{9}

Examples



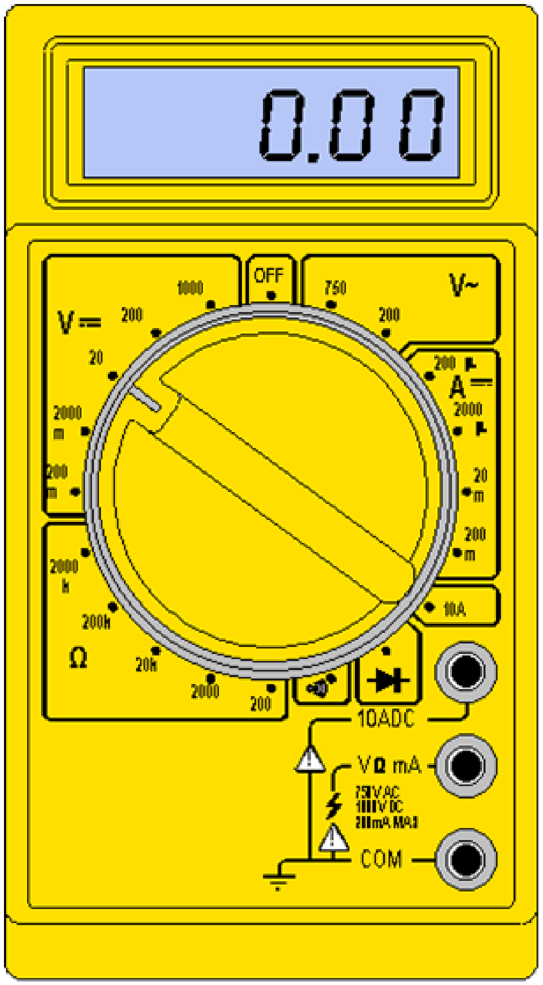
http://www.electrician.com/resist_calc/resist_calc.htm

Digital Multimeter 1



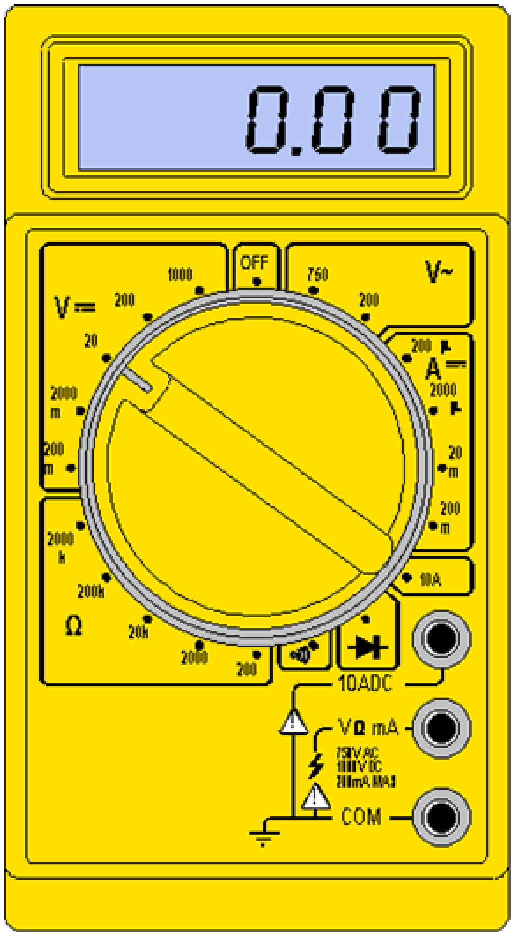
- DMM is a measuring instrument
- An **ammeter** measures current
- A **voltmeter** measures the potential difference (voltage) between two points
- An **ohmmeter** measures resistance
- A **multimeter** combines these functions, and possibly some additional ones as well, into a single instrument

Digital Multimeter 2

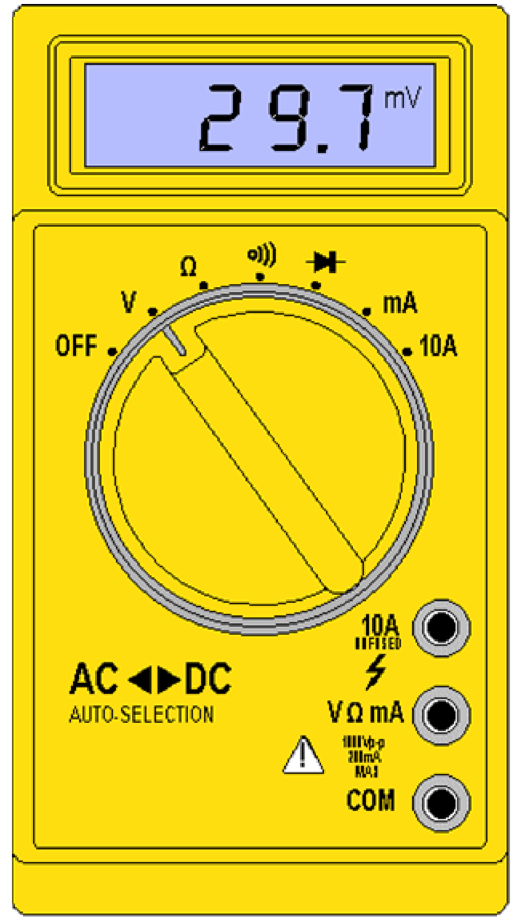


- Voltmeter
  - Parallel connection
- Ammeter
  - Series connection
- Ohmmeter
  - Without any power supplied
- Adjust range (start from highest limit if you don’t know)

Digital Multimeter 3

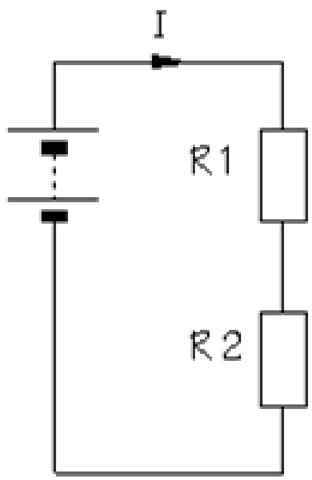


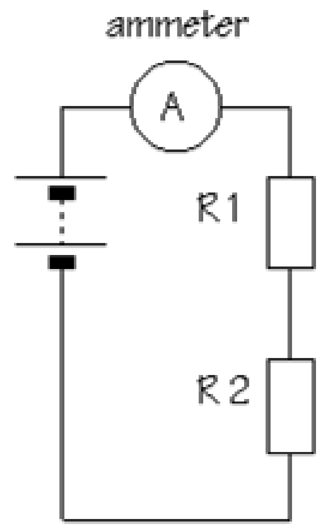
Switched Ranging DMM



Auto Ranging DMM

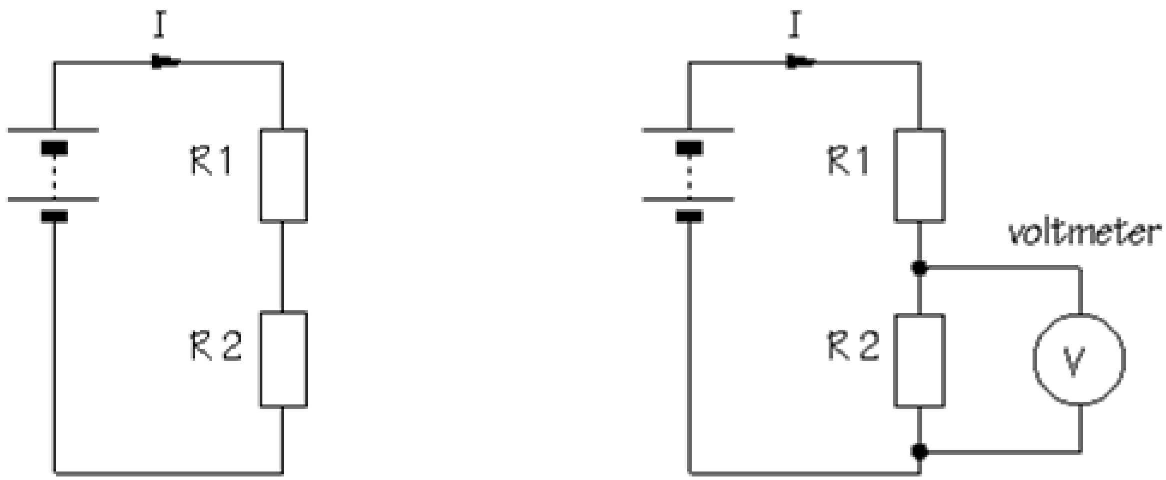
Ammeter Connection





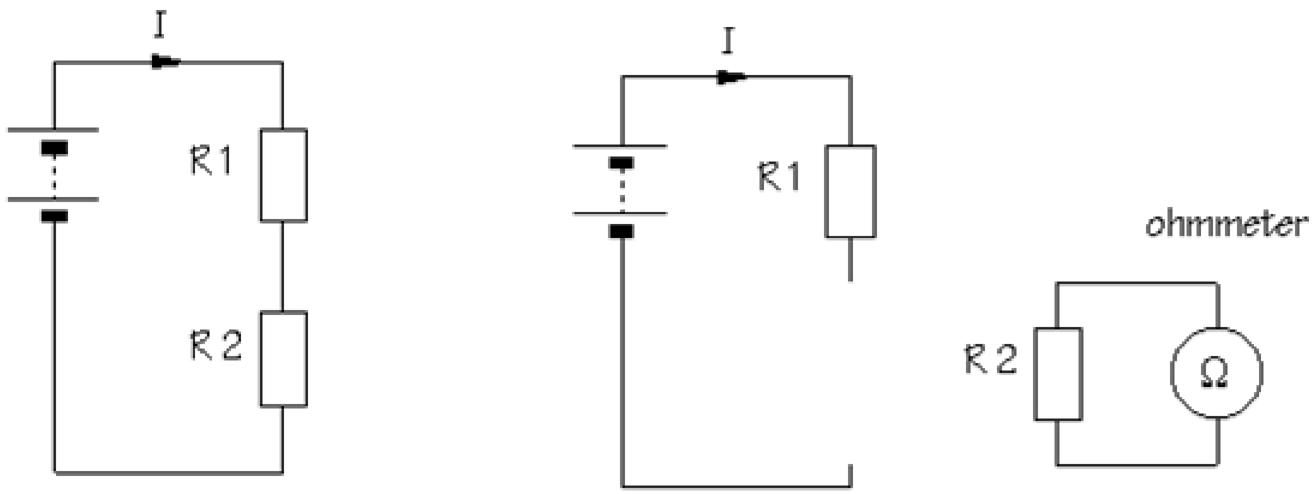
- Break the circuit so that the ammeter can be connected in series
- All the current flowing in the circuit must pass through the ammeter
- An ammeter must have a very LOW input impedance

Voltmeter Connection



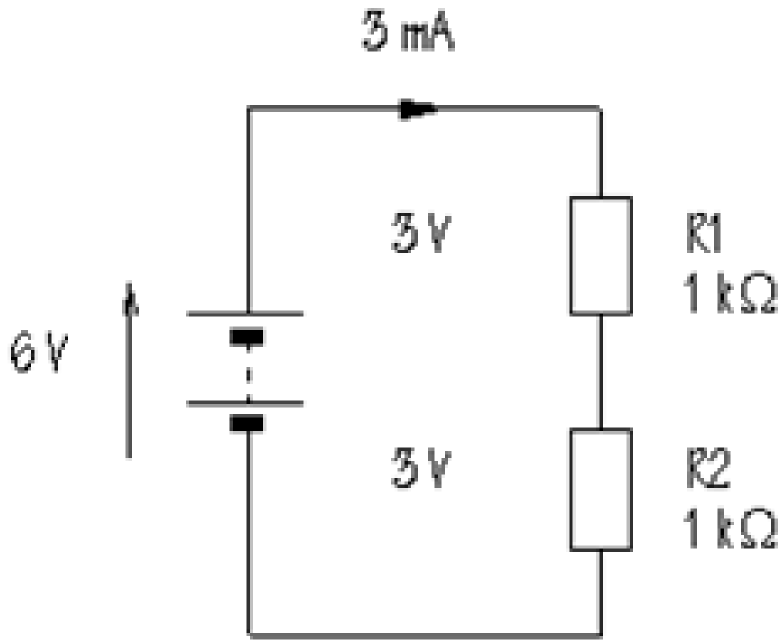
- The voltmeter is connected in parallel between two points of circuit
- A voltmeter should have a very HIGH input impedance

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

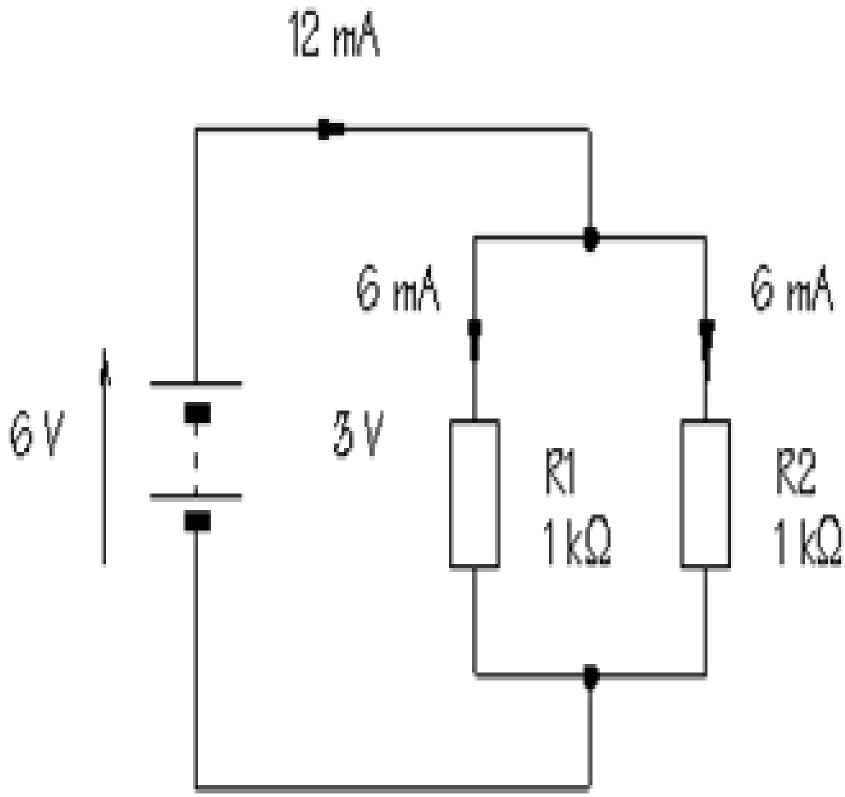
Resistors in Series



$R_{total}=R_1+R_2$

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

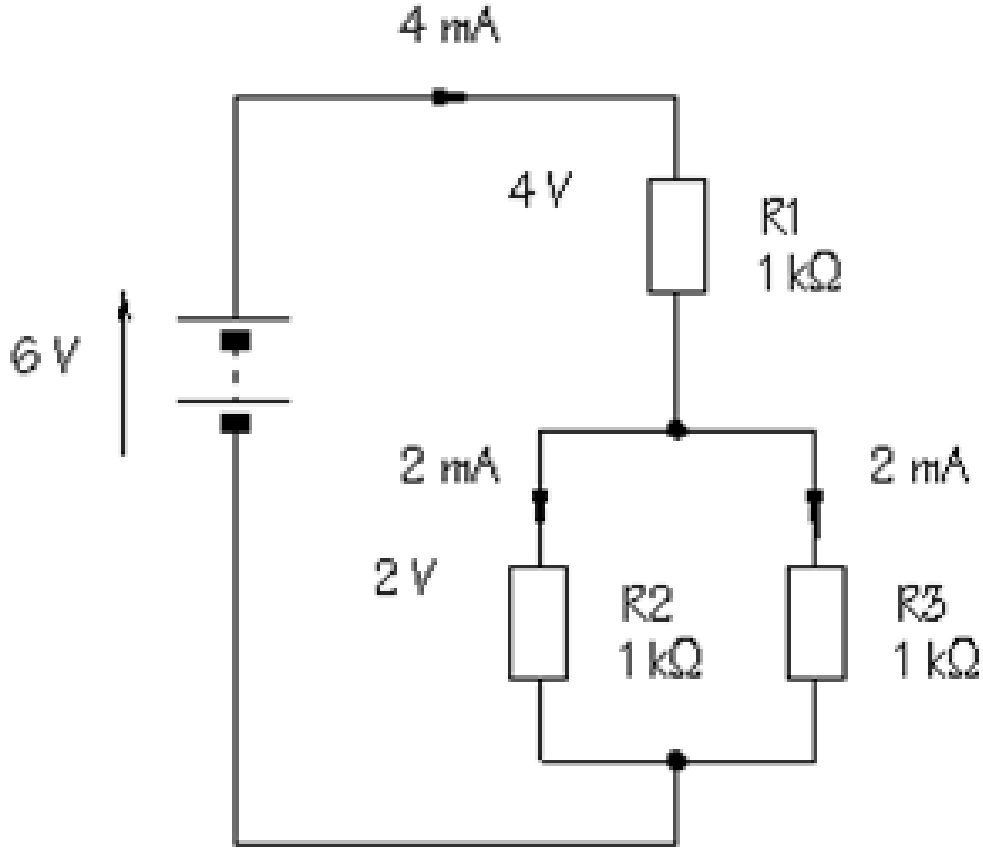
Resistors in Parallel



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

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

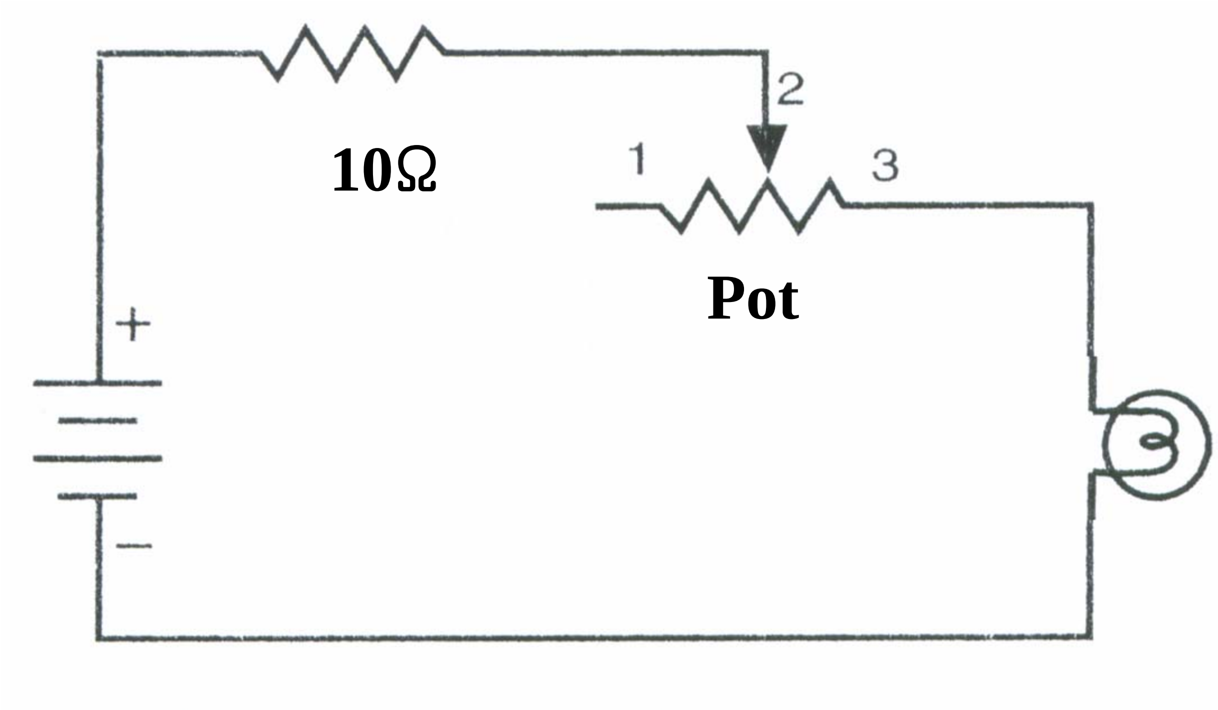
Exercise 1



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

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

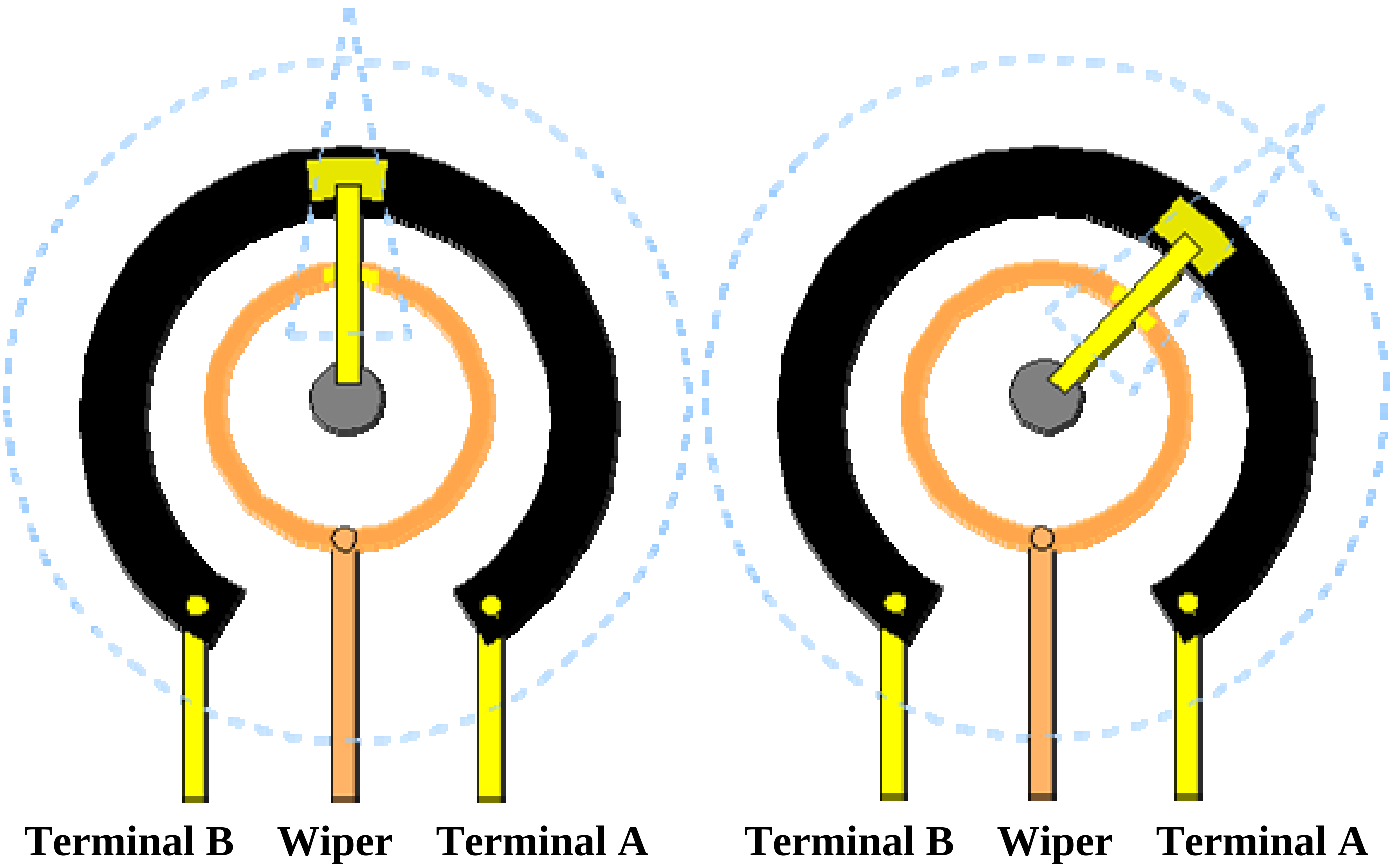
Exercise 2



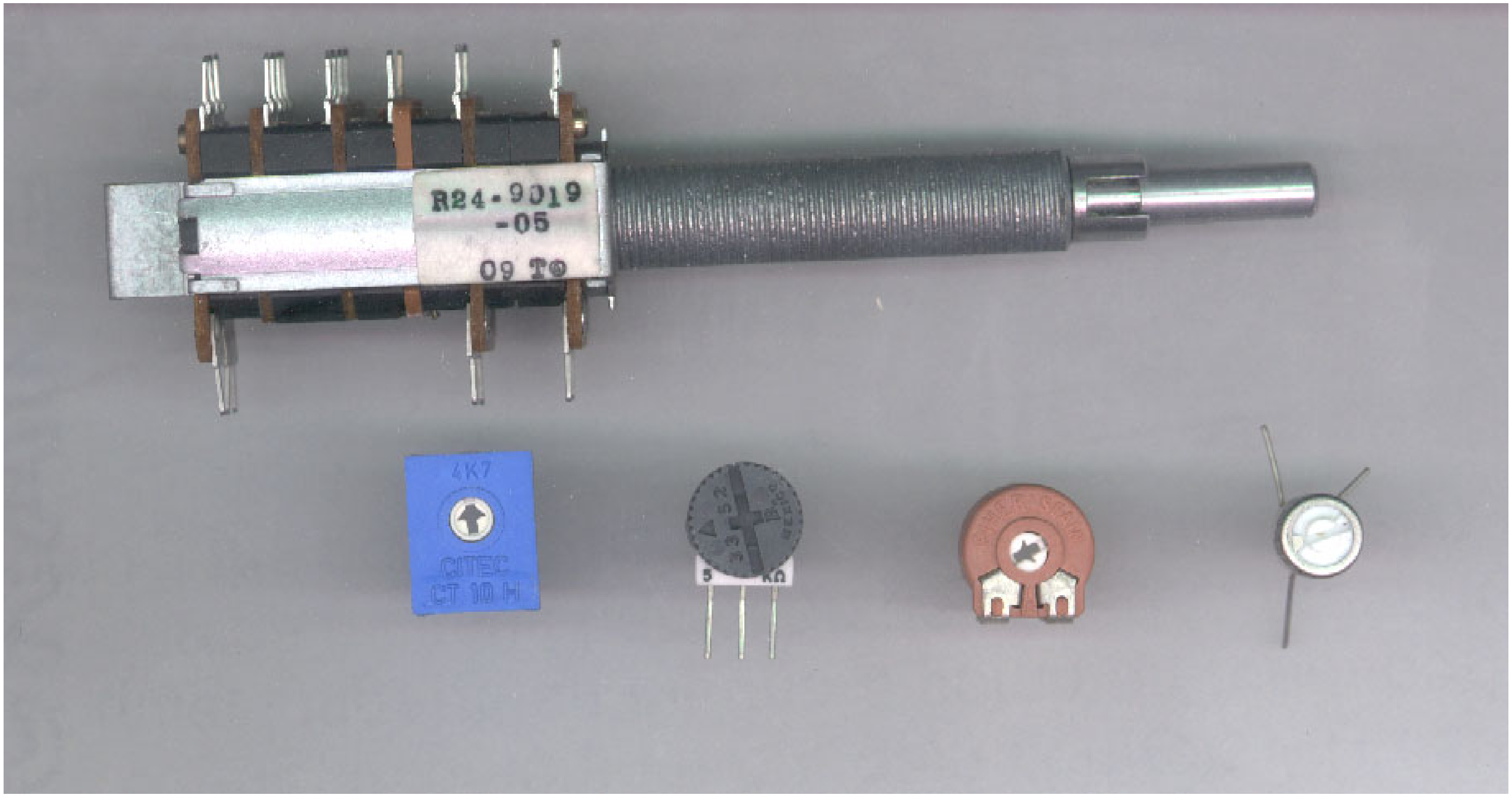
Potentiometer 1

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

Potentiometer 2

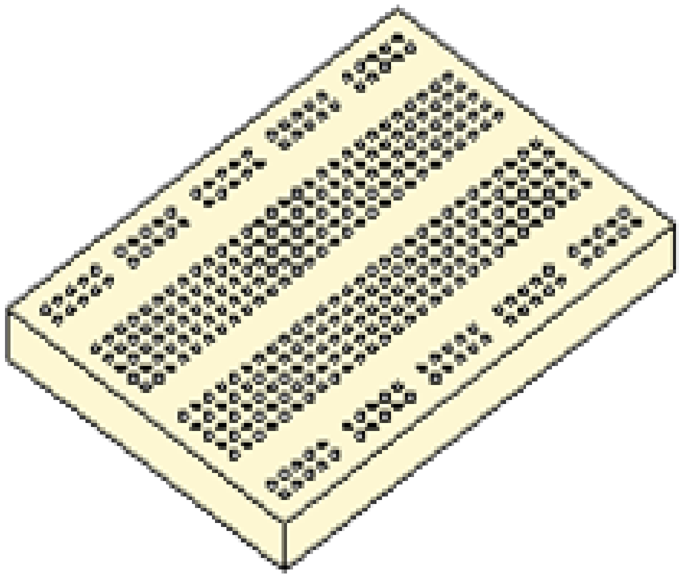


Rotary Potentiometers



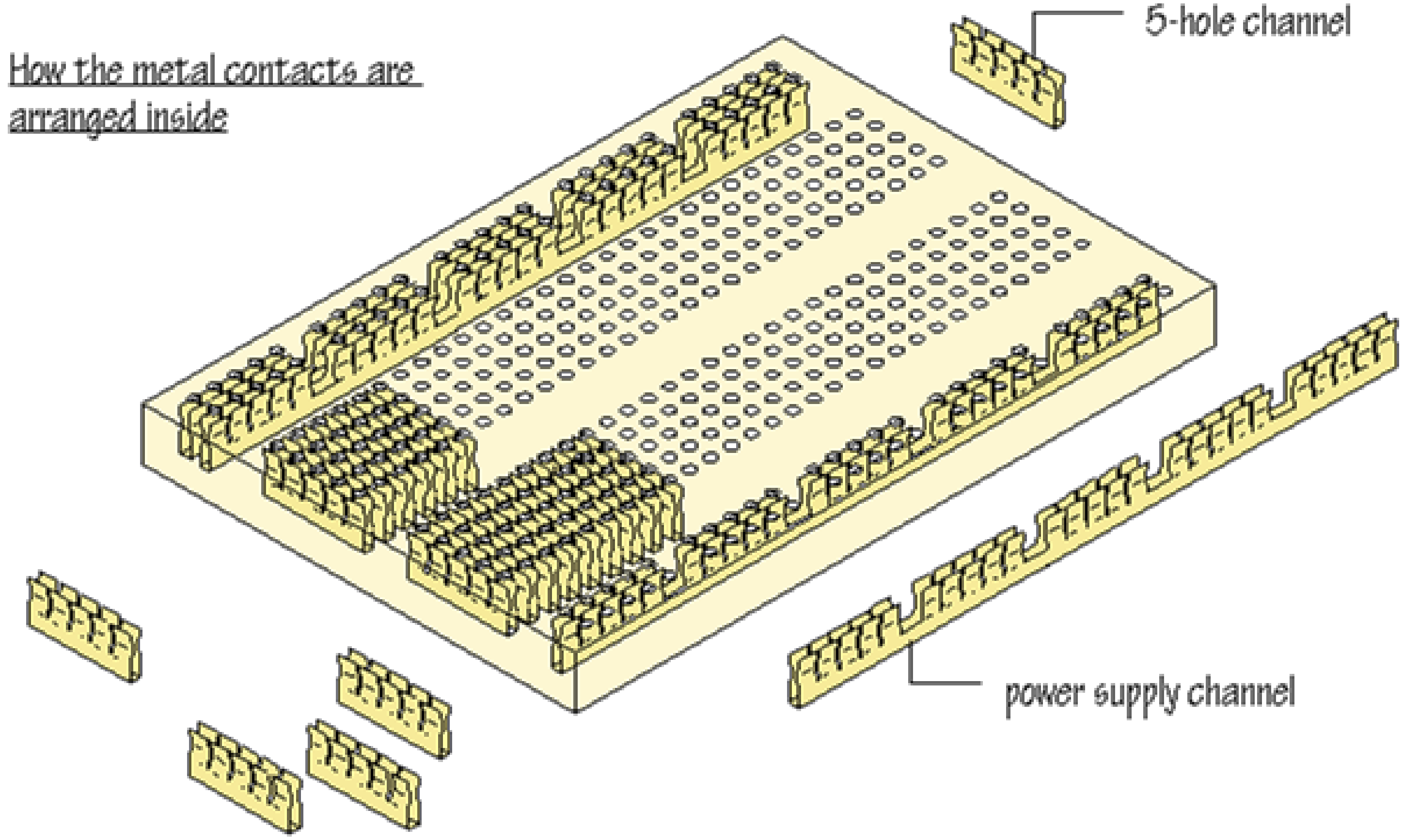
Linear Potentiometer

Breadboard 1

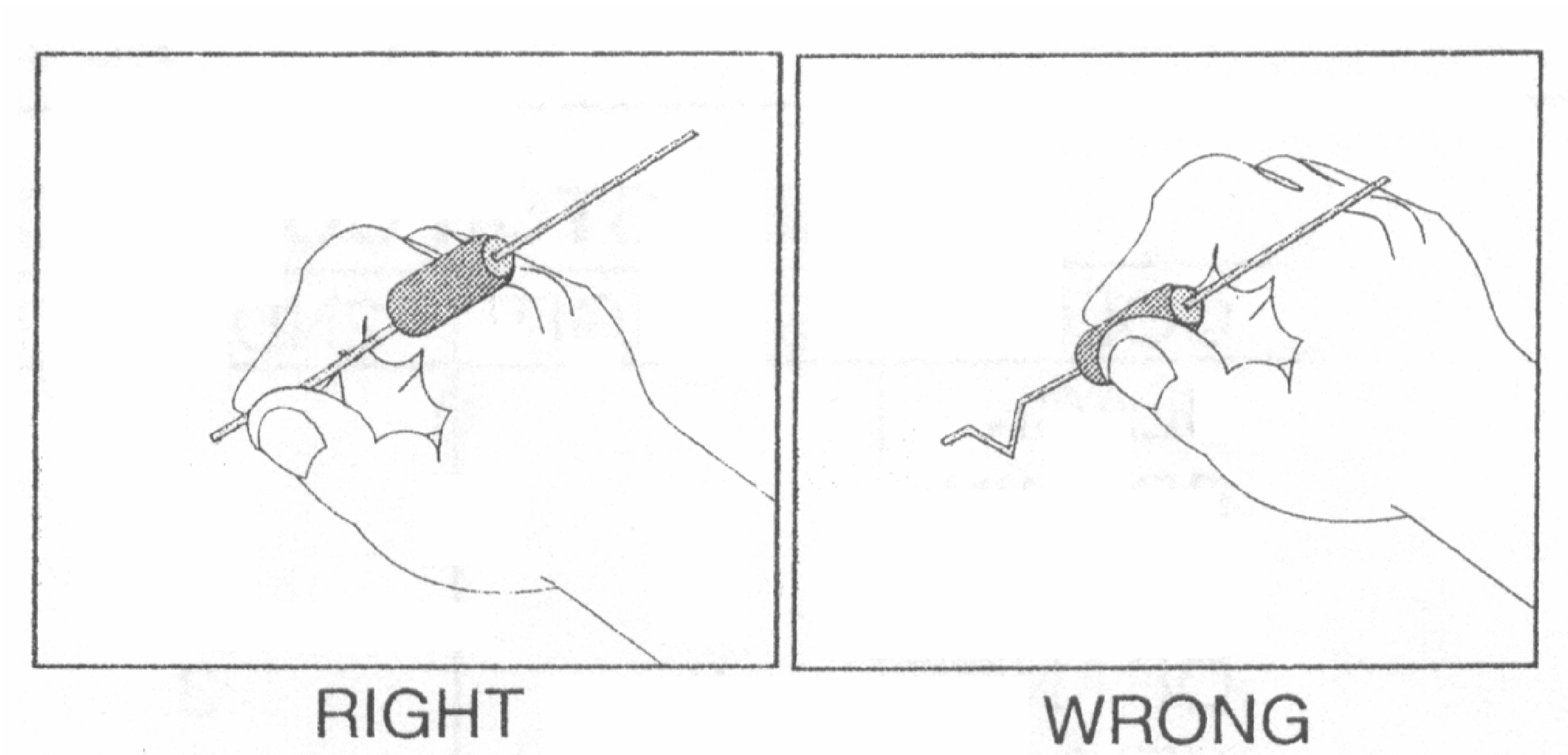


Prototype board is used for building temporary circuits, without soldering. Component leads are pushed into the holes in the board to make connections.

Breadboard 2



How to Insert a Component into a Breadboard



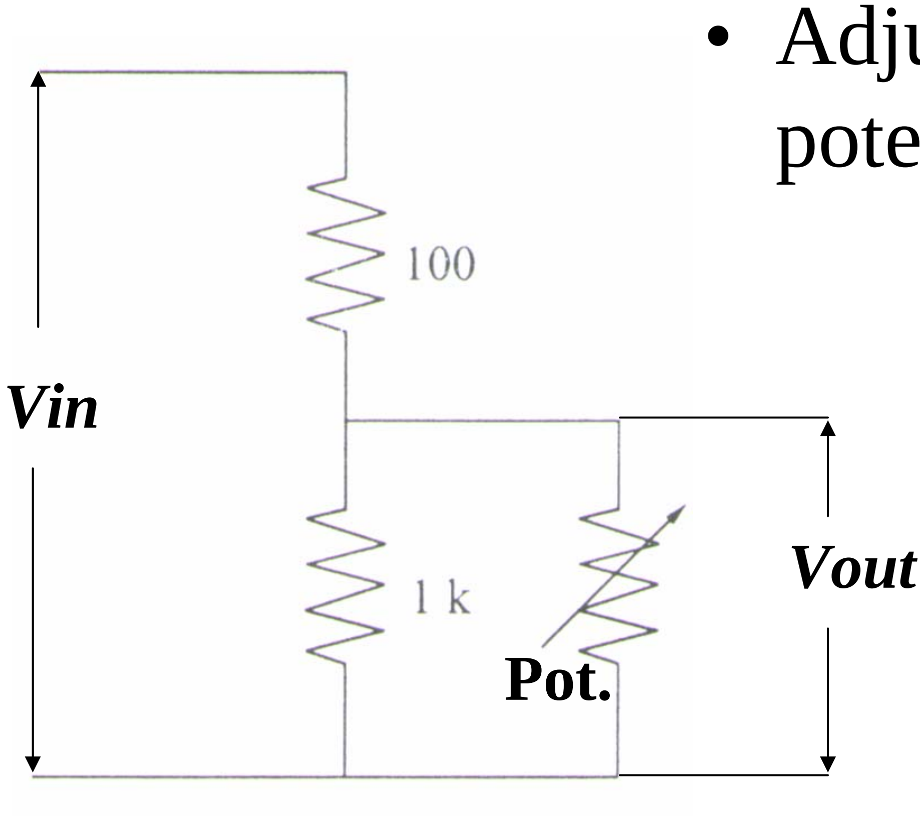
Resistor Experiments

Experiments	Chapters
What's micro controller	
Basic A and D	
Process Control	
Smart Sensors	
Boe Bot Robotics	
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

$$Vout = \frac{5}{6} Vin$$

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

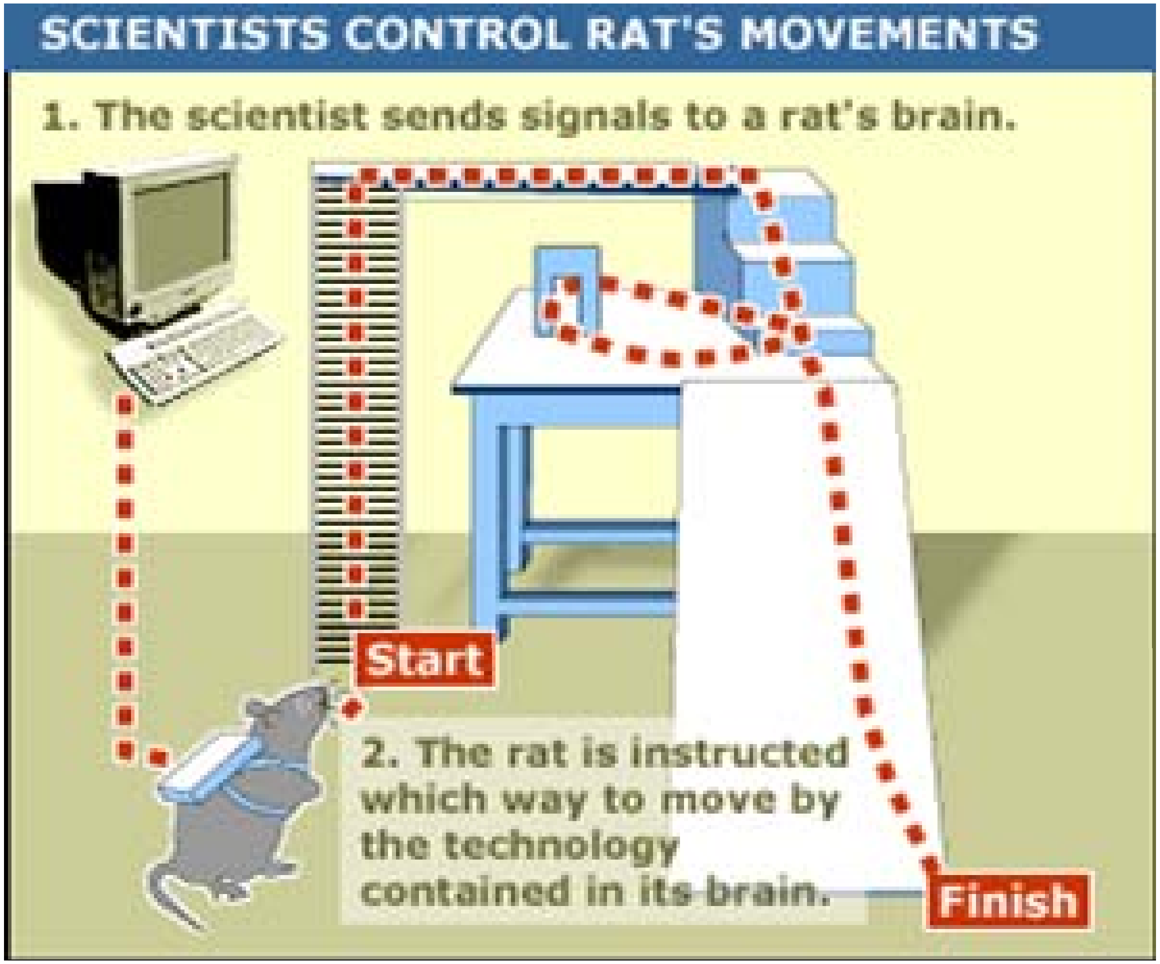
Mechatronic Applications

- **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

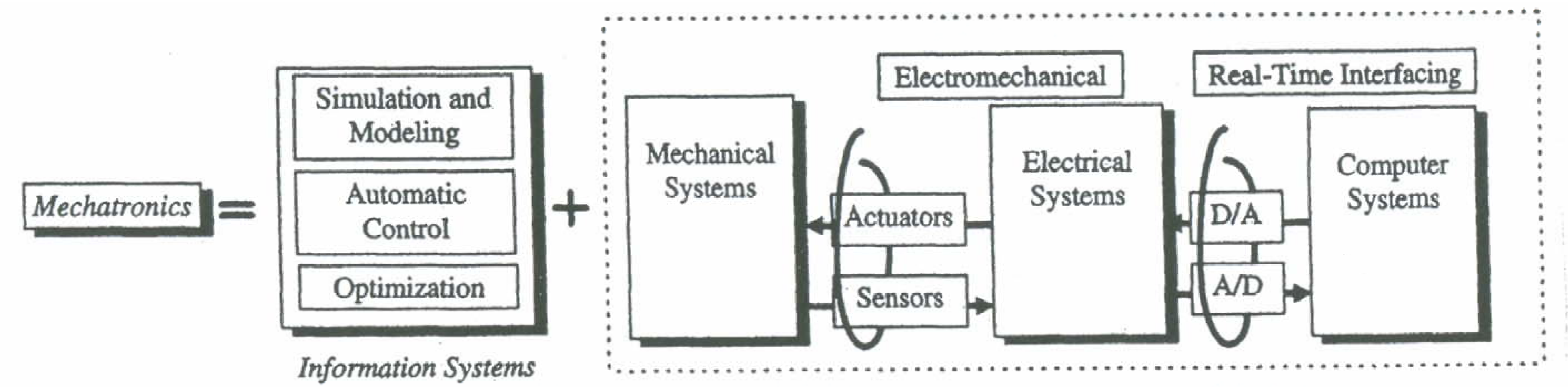
Roborat 2

Roborat 3


SCIENTISTS CONTROL RAT'S MOVEMENTS
1. The scientist sends signals to a rat's brain.
Start
2. The rat is instructed which way to move by the technology contained in its brain.
Finish

Robocockroach

Key Elements of Mechatronics



Elements of Mechatronics 1

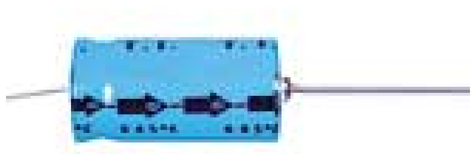
- Mechanical elements

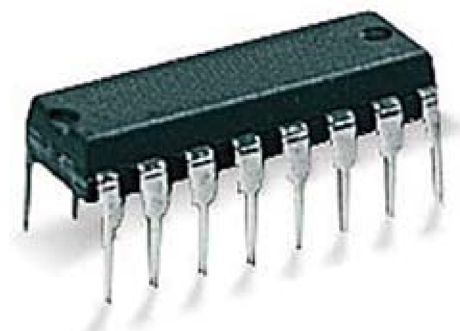
Elements of Mechatronics 2

- Electromechanical elements

Elements of Mechatronics 3

- Electrical/Electronic elements



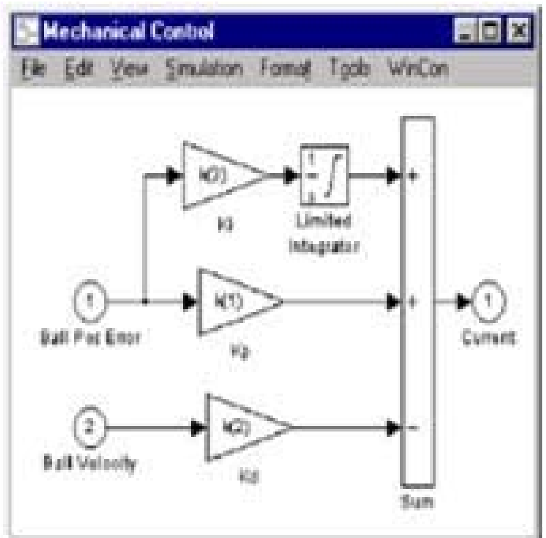


Elements of Mechatronics 4

- Control interface/computing hardware elements

Elements of Mechatronics 4

- Computer elements



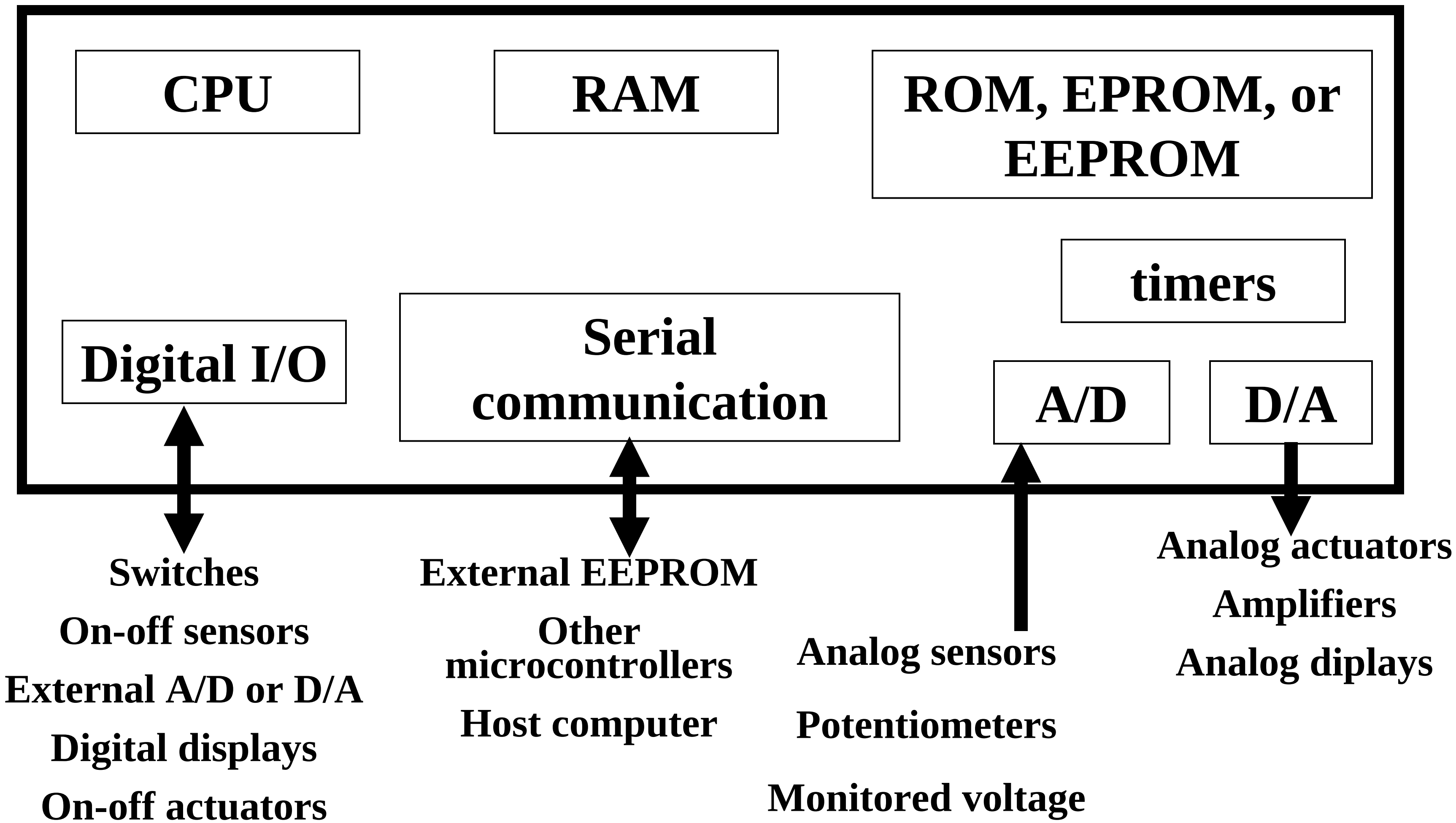
Microprocessors

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

Microcontrollers

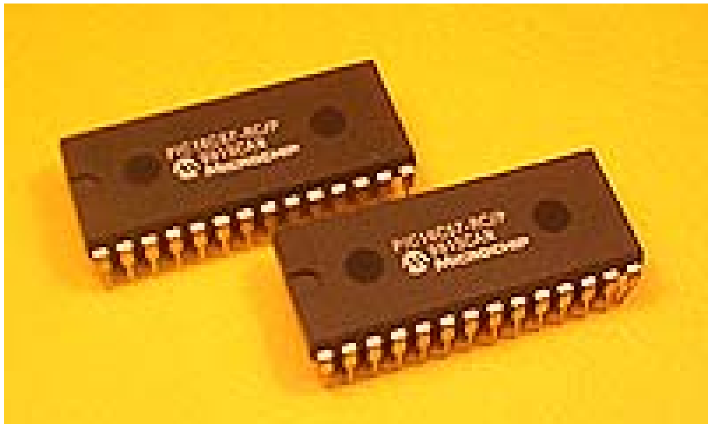
- Special purpose miniaturized computers
- Single integrated circuit containing many specialized and sophisticated circuits and functions
- Two primary components
  - RAM
  - CPU with instruction set

Microcontroller Architecture

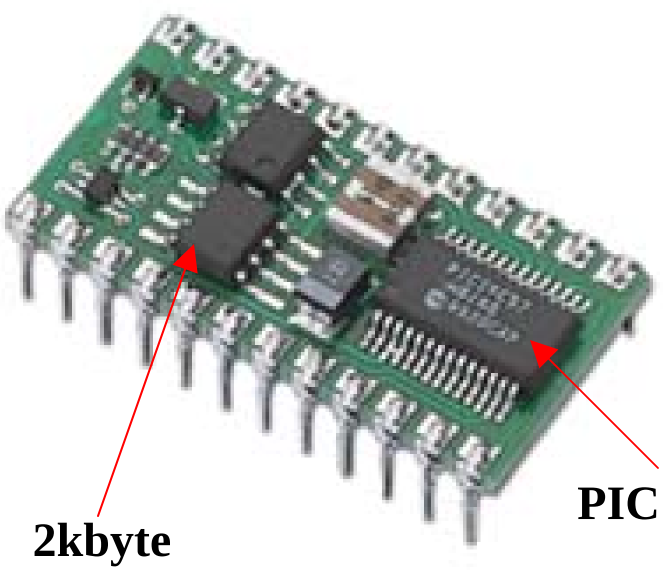


PIC Microcontrollers

- 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

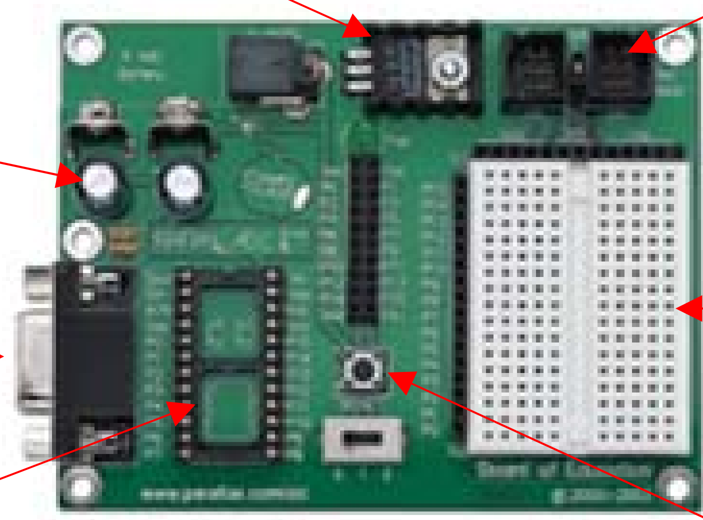
Stamp Development Board

5V Voltage regulator

Servomotor connector

Caution!!

Capacitors



DB9 connector

Breadboard

BS2 socket

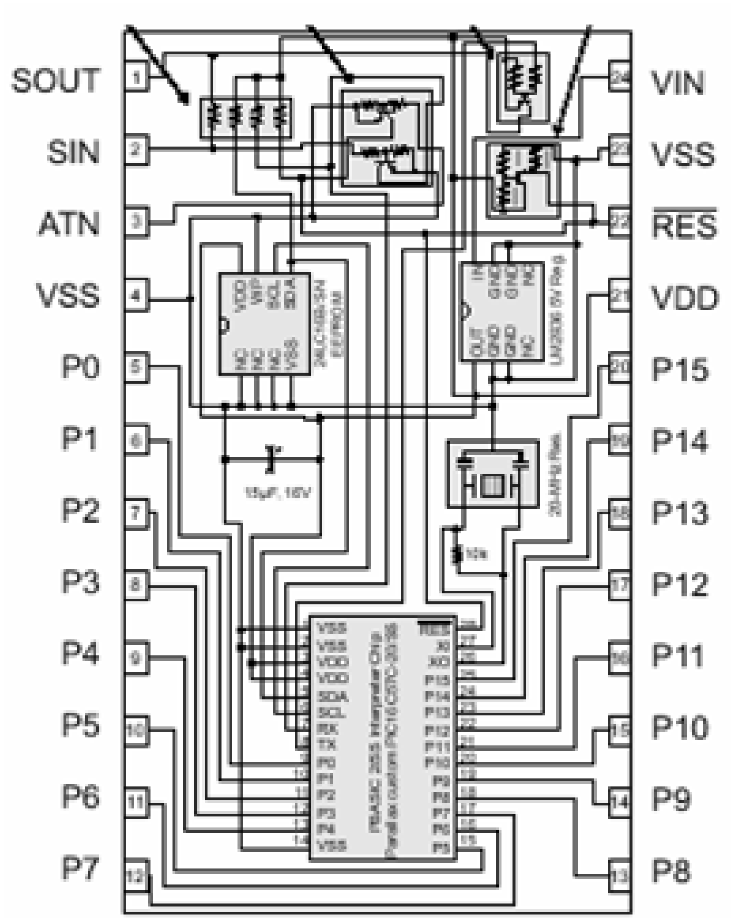
Reset button

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

Result is 119

$$01110111 = 2^7(0)+2^6(1)+2^5(1)+2^4(1)$$
$$+2^3(0)+2^2(1)+2^1(1)+2^0(1)$$
$$= 119$$

Assigning Pins for I/O

DIRS: 1 for output, 0 for input

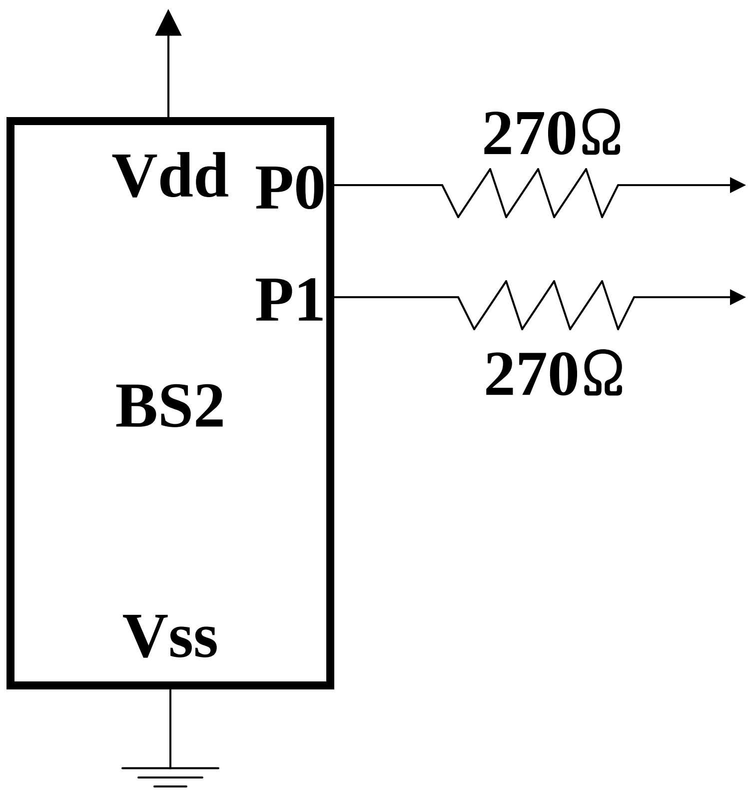
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DIR D				DIR C				DIR B				DIR A			
DIR H								DIR L							

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	
Process Control	
Smart Sensors	
Boe Bot Robotics	
Others	On coming slides

Experiment Details 1

myCon CON 10

myVar1 VAR Byte

myVar2 VAR Byte

myVar3 VAR word

myVar4 VAR word

myVar1=5

myVar2=25

myVar3=375

myVar4=400

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 Syntax and Reference Manual ” from page 1 to page 75
- And DEBUG on page 159