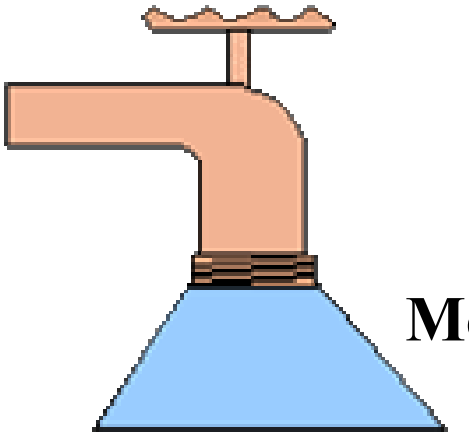
Lecture 1

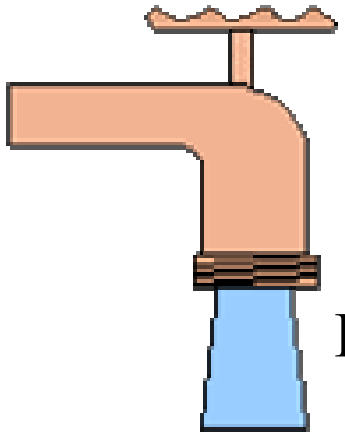
What is Current?

- 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



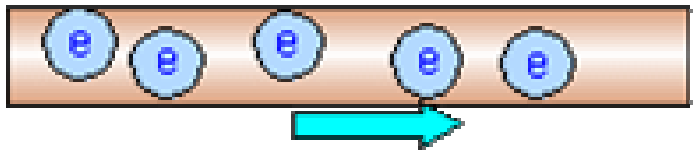
More current



Less current

More current

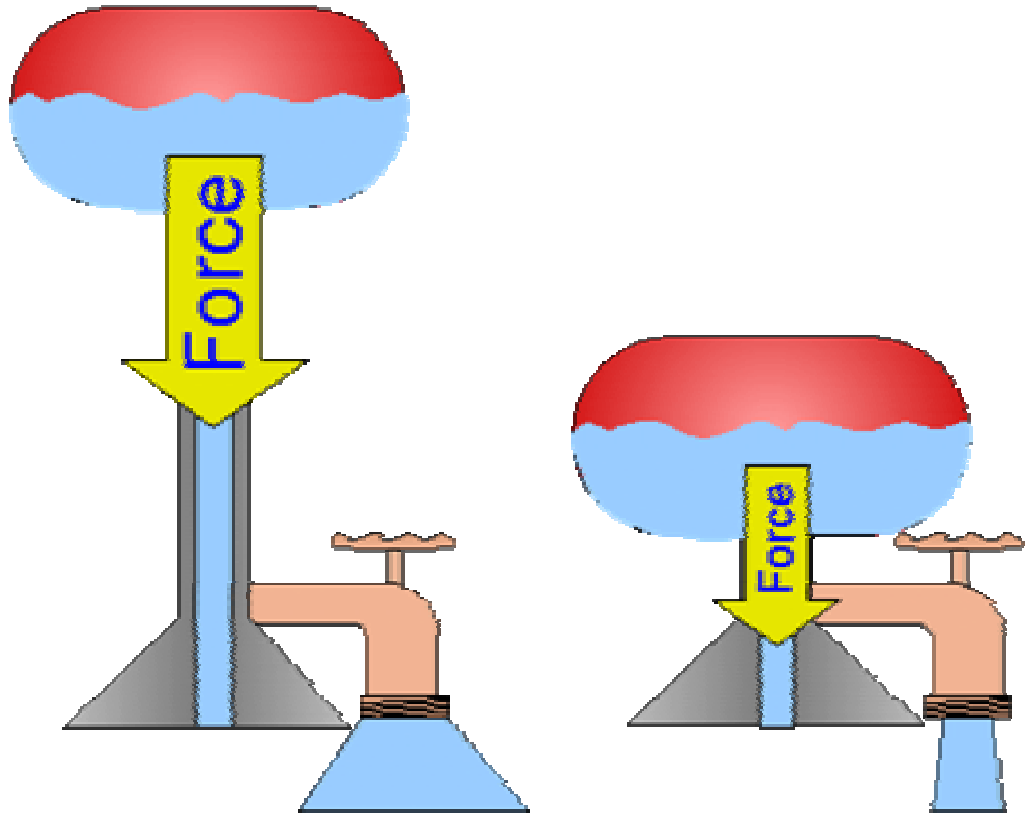
Less current



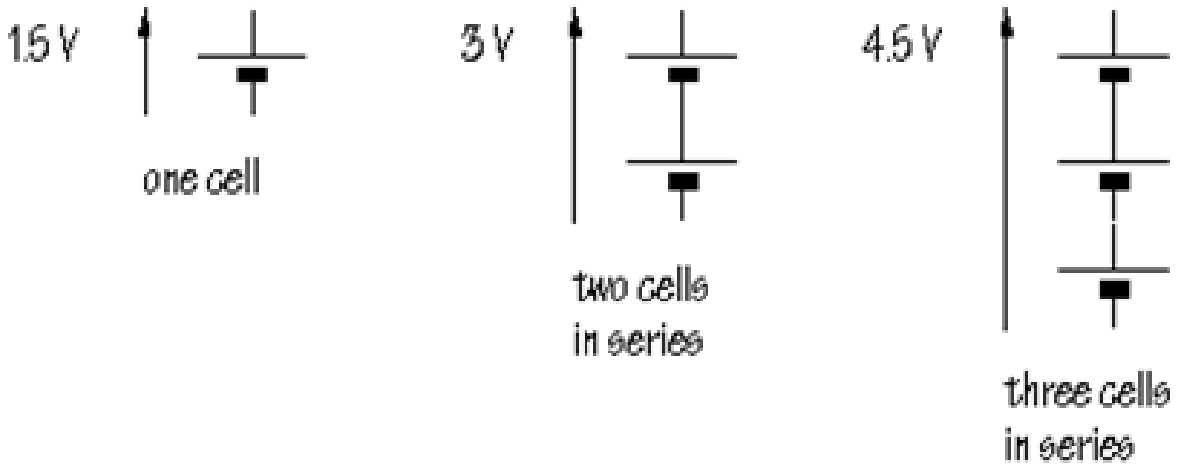
What is Voltage?

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

Water Analogy

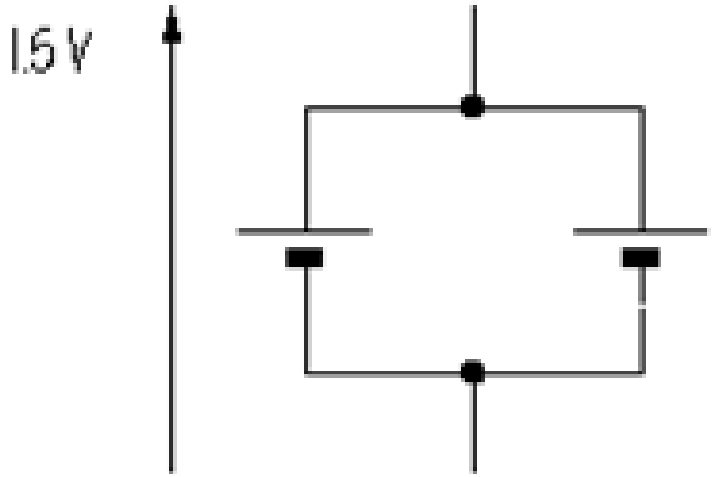


Series Connection of Cells



- 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

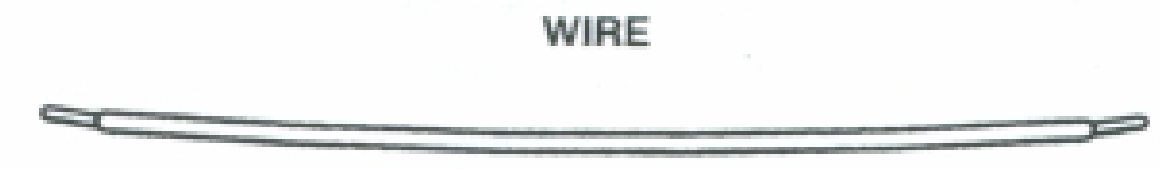
- A cell provides a steady voltage, so that current flow is always in the same direction
  - This is called **direct current**, or **d.c**
- The domestic mains provides a constantly changing voltage which reverses in polarity 60 times every second
  - This gives rise to **alternating current**, or **a.c**

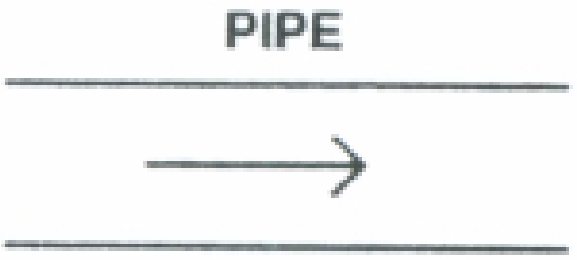
Power Supply

Digital

Analog

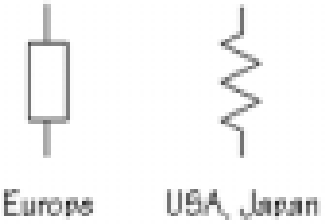
Water Analogy of Wires



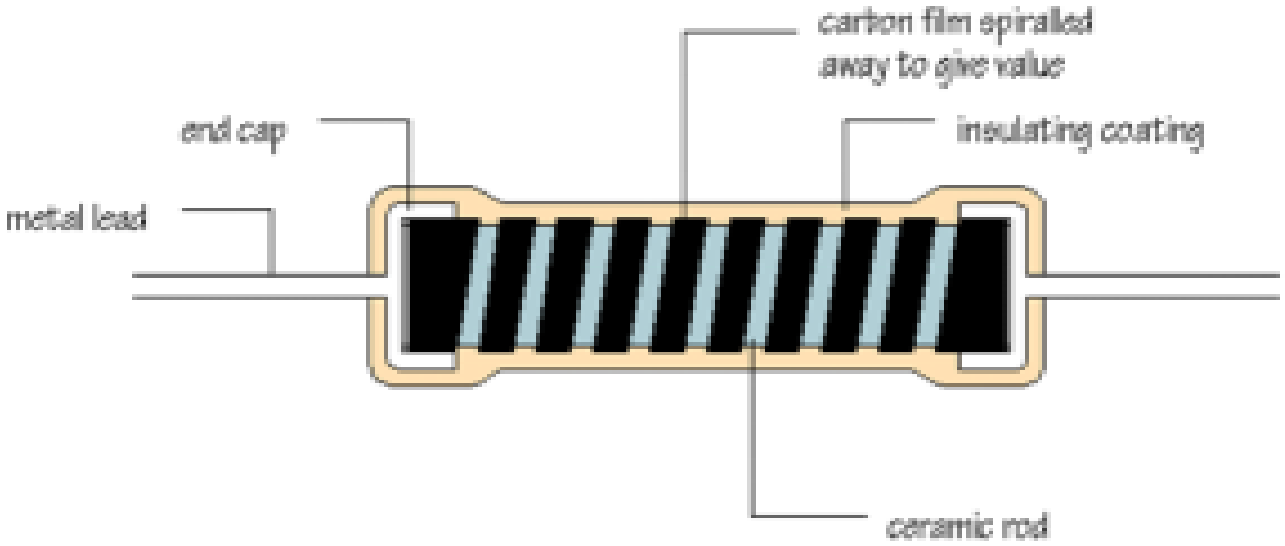


Resistors

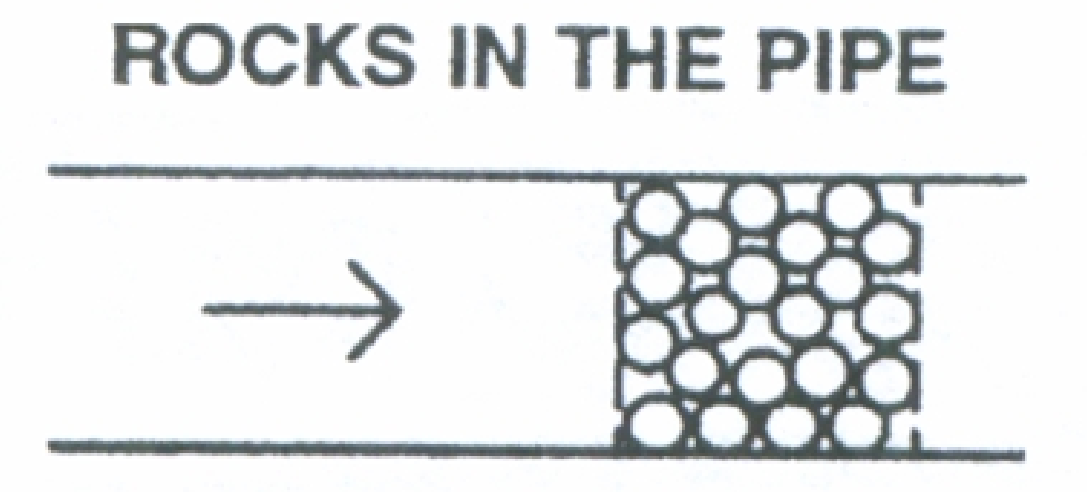
- Dissipative elements that convert electrical energy into heat
- Resistors limit current
- Unit is **ohms**, Ω



Resistor Symbols



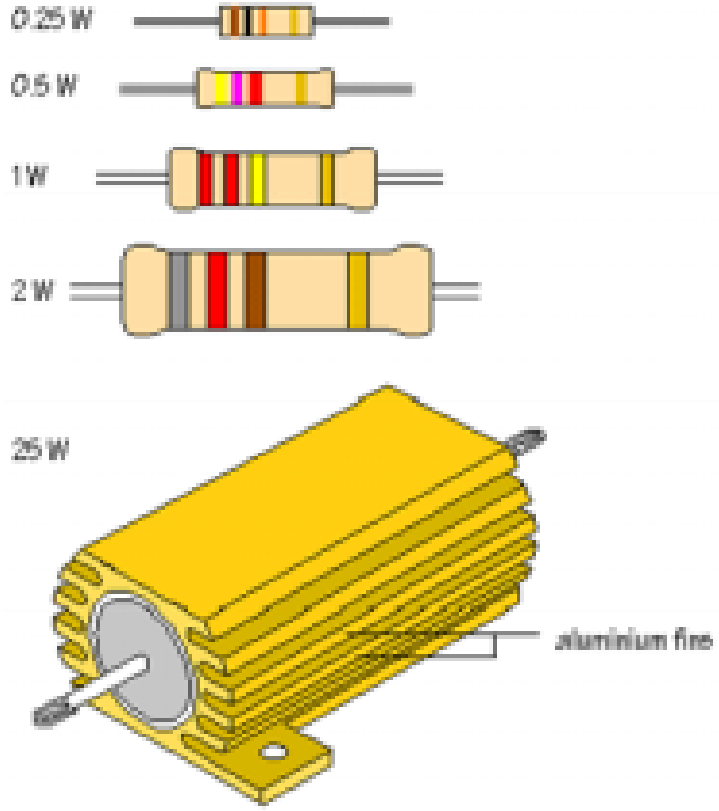
Water Analogy of Resistor

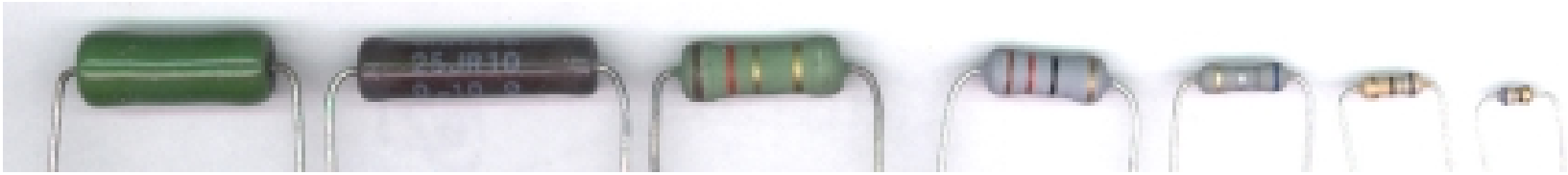


Resistor Applications

- 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



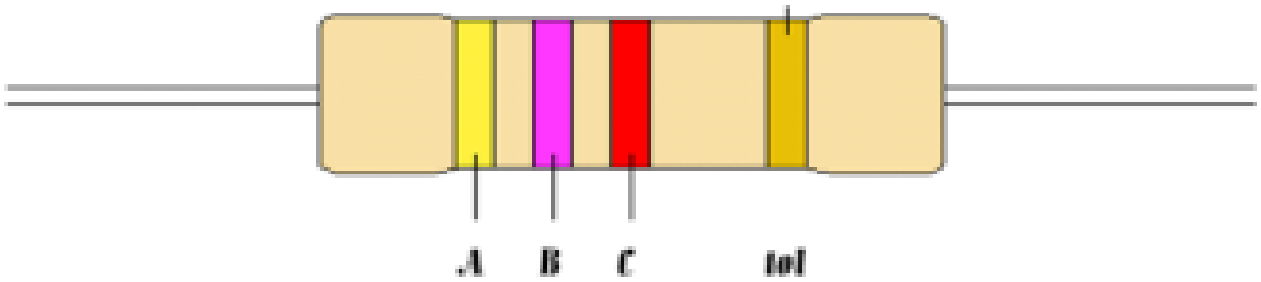


How to Read Resistor Values 1

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

How to Read Resistor Values 2

By color code



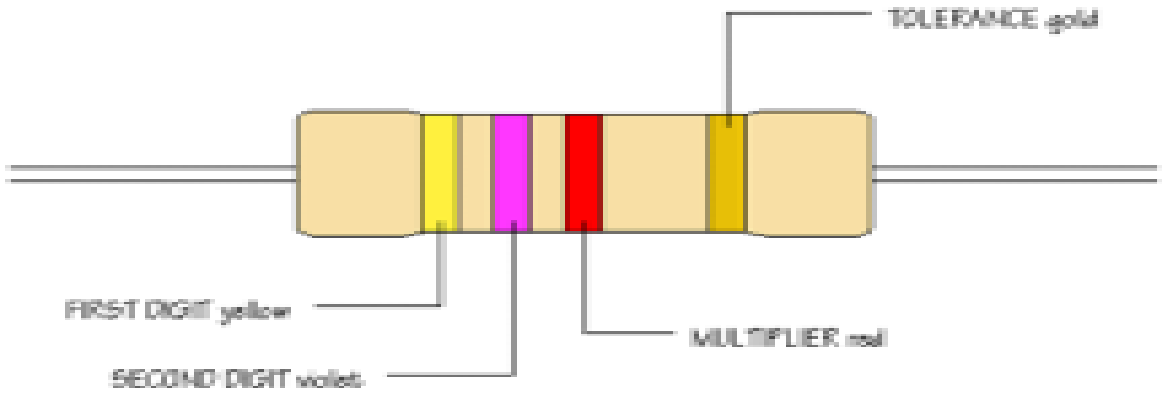
$$\text{Resistor value} = AB \times 10^{C} \pm tol\%(\Omega)$$

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*
±1%	brown
±2%	red
±5%	gold
±10%	silver

Example

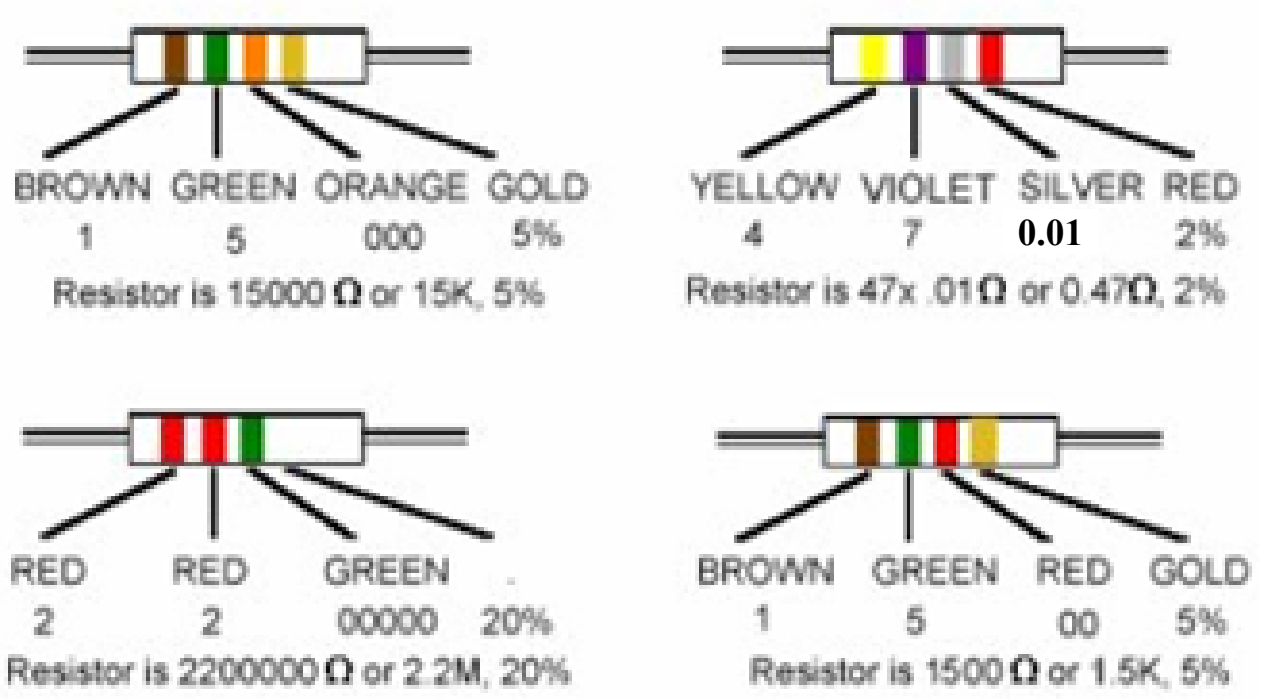


- The first band is yellow, so the first digit is 4
- The second band is violet, so the second digit is 7
- The third band is red, so the multiplier is 10^2
- Resistor value is $47 \times 10^2 \pm 5\%(\Omega)$

Metric Units and Conversions

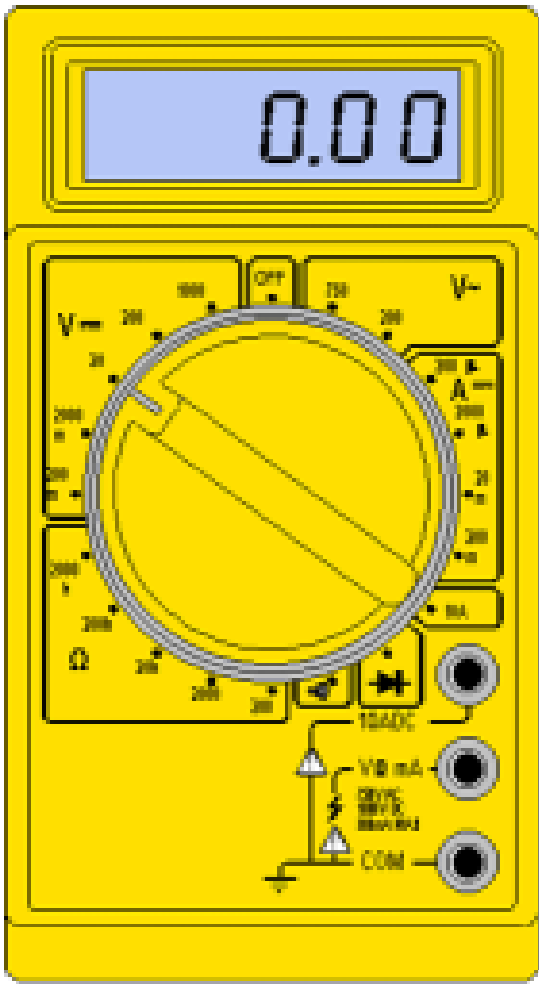
Abbreviation	Means	Multiply unit by	Or
p	pico	.000000000001	10^{-12}
n	nano	.000000001	10^{-9}
μ	micro	.000001	10^{-6}
m	milli	.001	10^{-3}
.	Unit	1	10^{0}
k	kilo	1,000	10^{3}
M	mega	1,000,000	10^{6}
G	giga	1,000,000,000	10^{9}

Examples



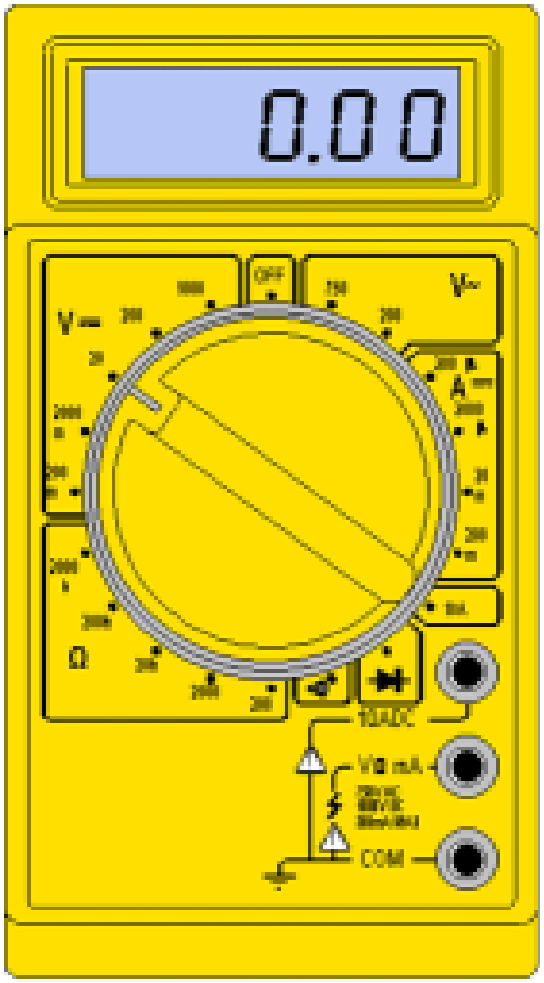
http://www.electrician.com/resist_calc/resist_calc.htm

Digital Multimeter 1



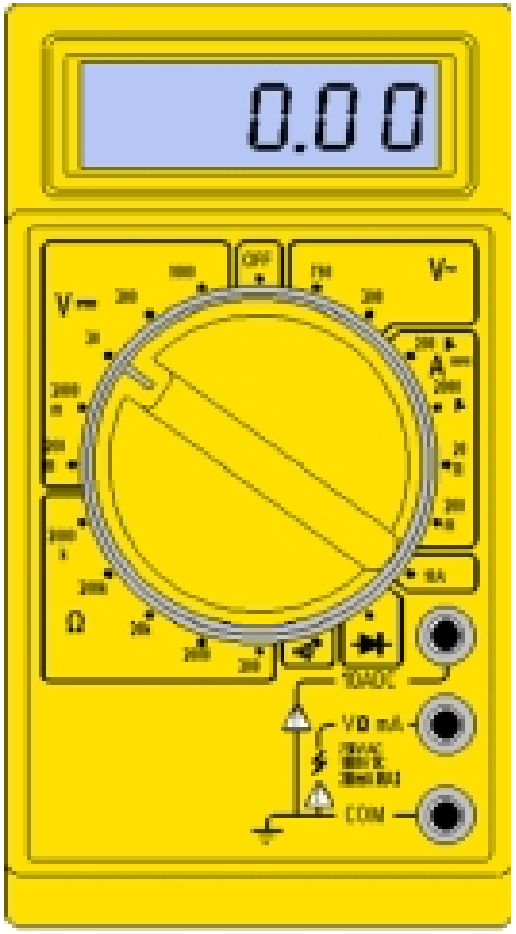
- DMM is a measuring instrument
- An **ammeter** measures current
- A **voltmeter** measures the potential difference (voltage) between two points
- An **ohmmeter** measures resistance
- A **multimeter** combines these functions, and possibly some additional ones as well, into a single instrument

Digital Multimeter 2

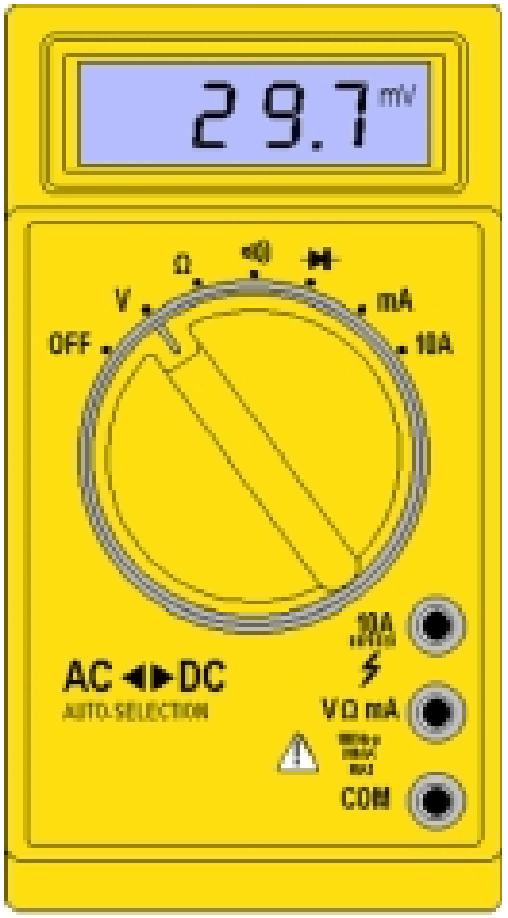


- Voltmeter
  - Parallel connection
- Ammeter
  - Series connection
- Ohmmeter
  - Without any power supplied
- Adjust range (start from highest limit if you don't know)

Digital Multimeter 3

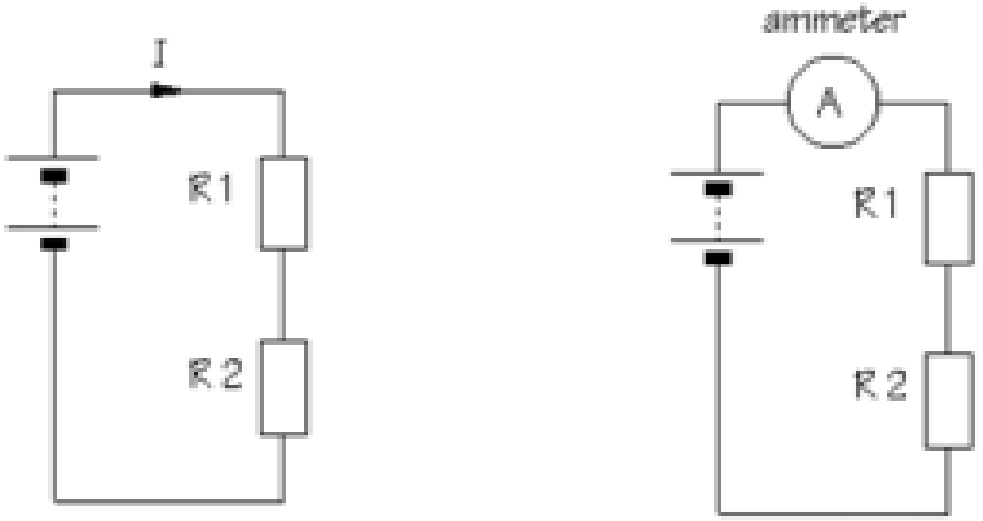


Switched Ranging DMM



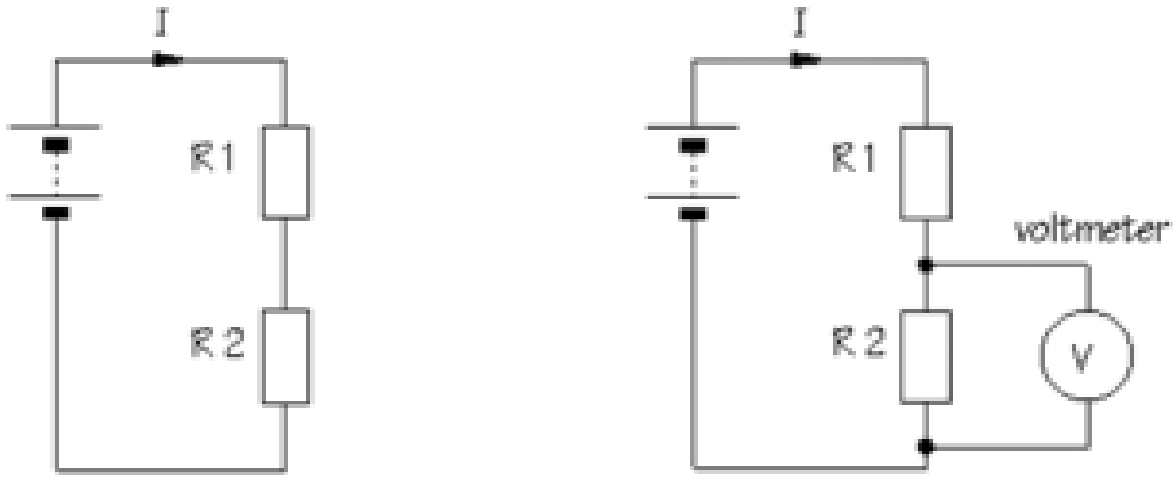
Auto Ranging DMM

Ammeter Connection



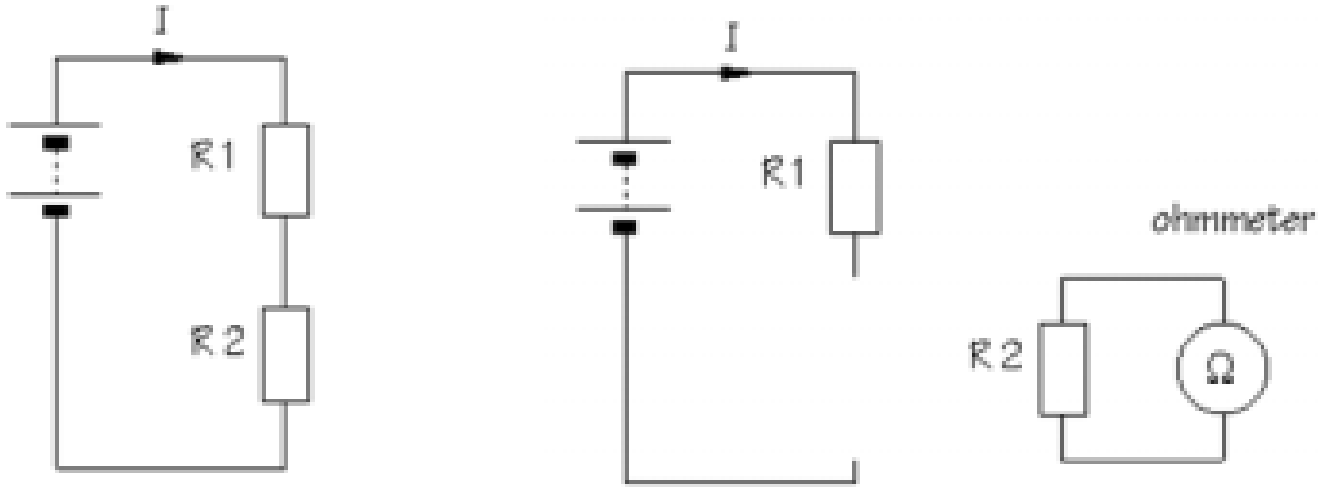
- Break the circuit so that the ammeter can be connected in series
- All the current flowing in the circuit must pass through the ammeter
- An ammeter must have a very LOW input impedance

Voltmeter Connection



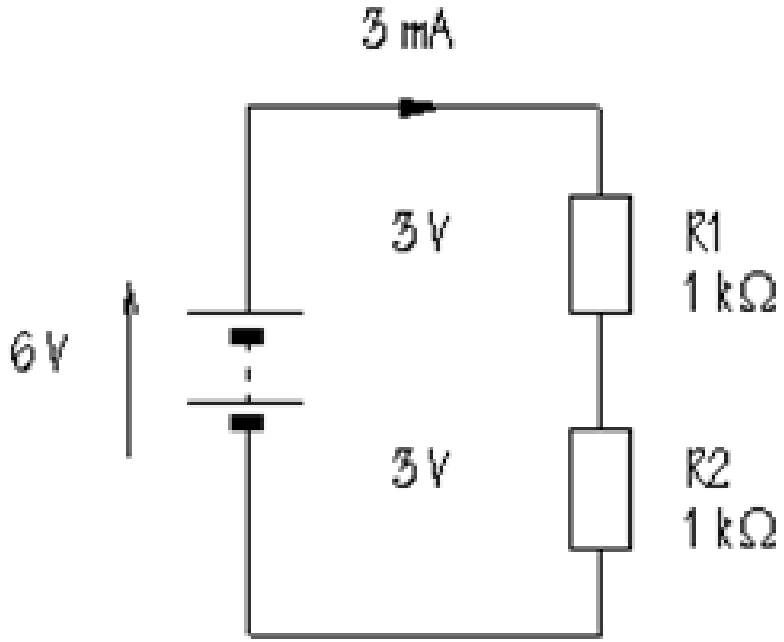
- The voltmeter is connected in parallel between two points of circuit
- A voltmeter should have a very HIGH input impedance

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

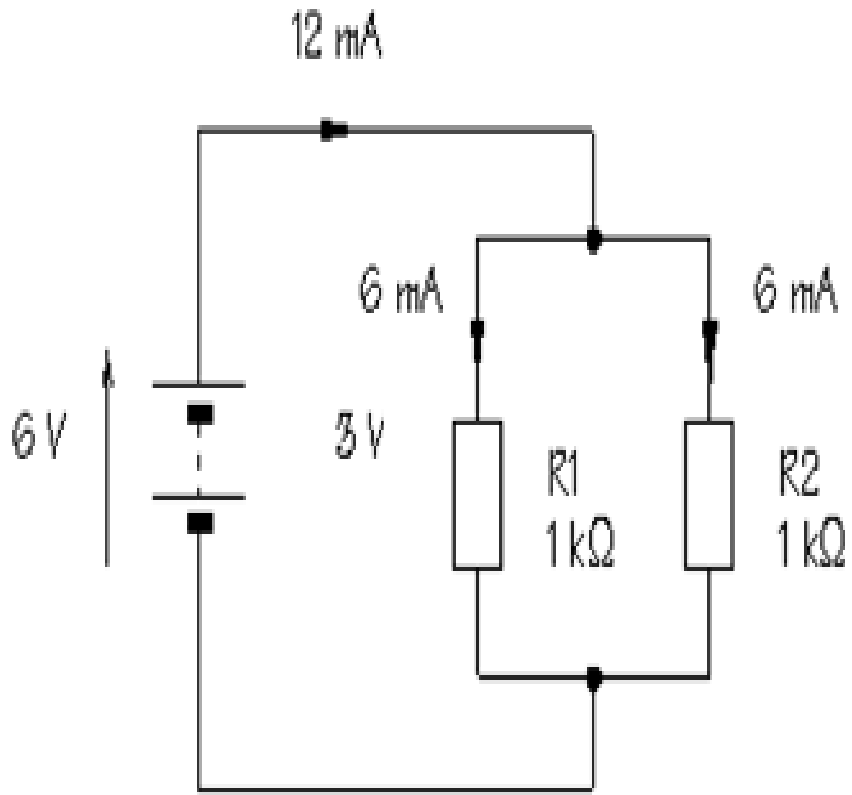
Resistors in Series



$R_{total}=R_1+R_2$

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

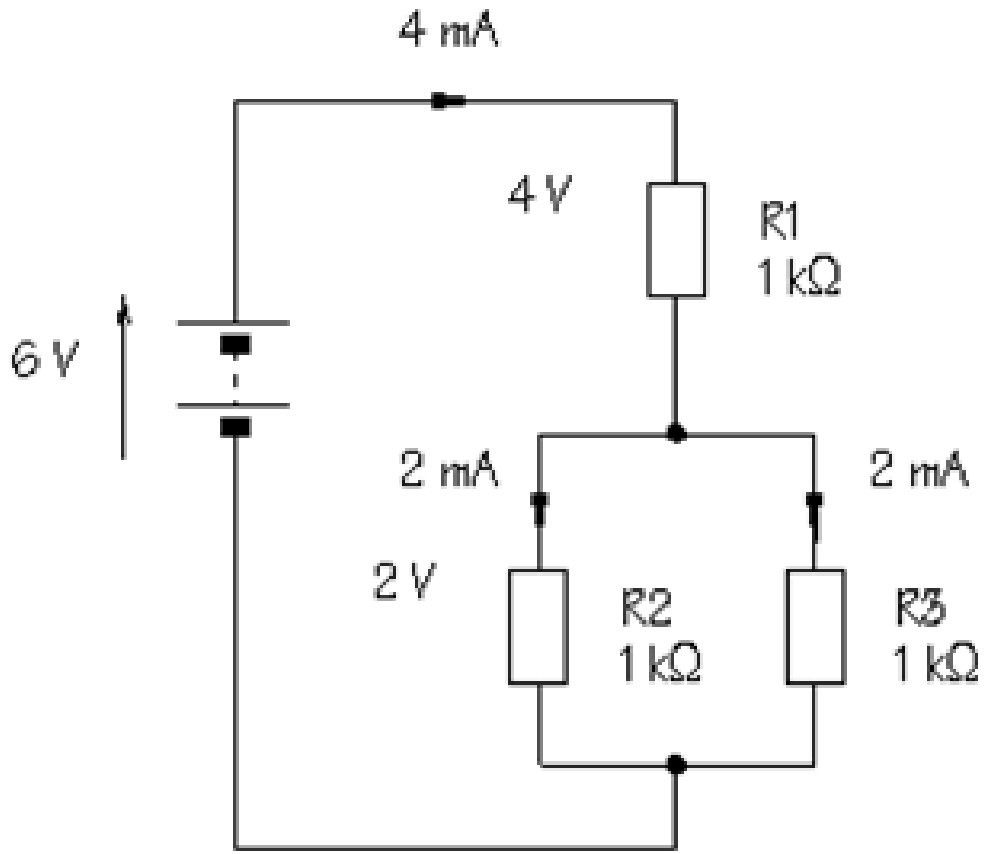
Resistors in Parallel



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

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

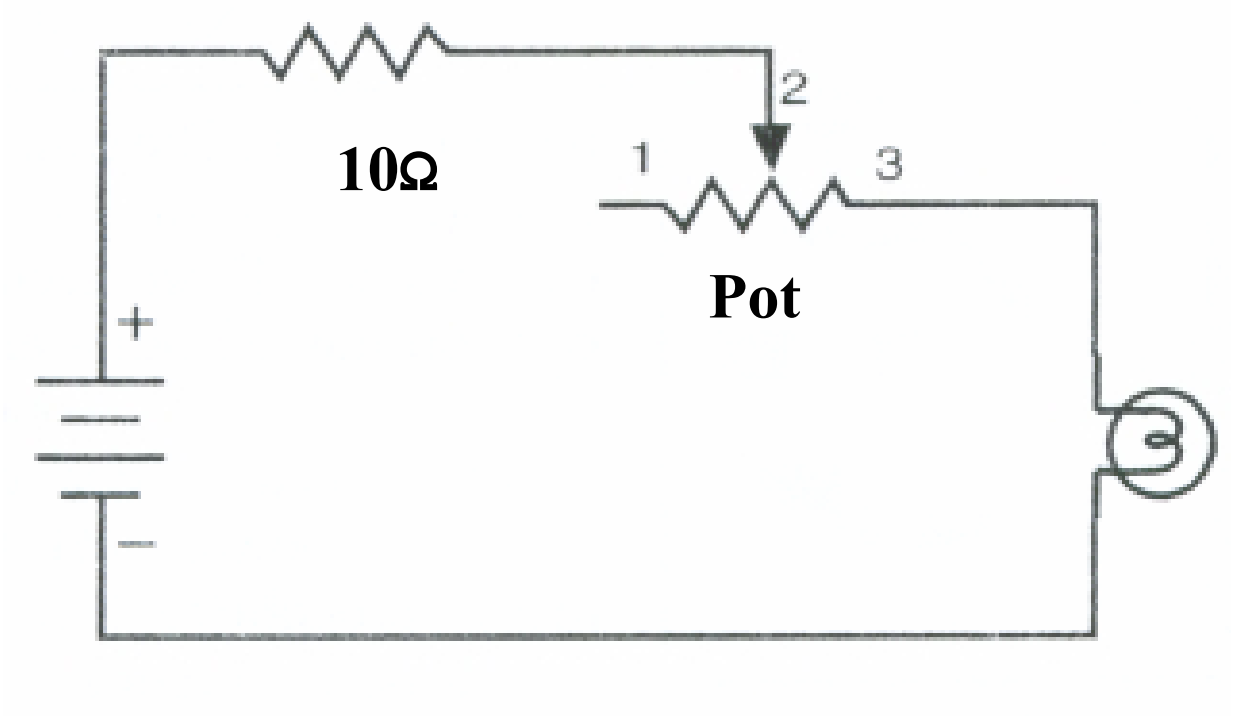
Exercise 1



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

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

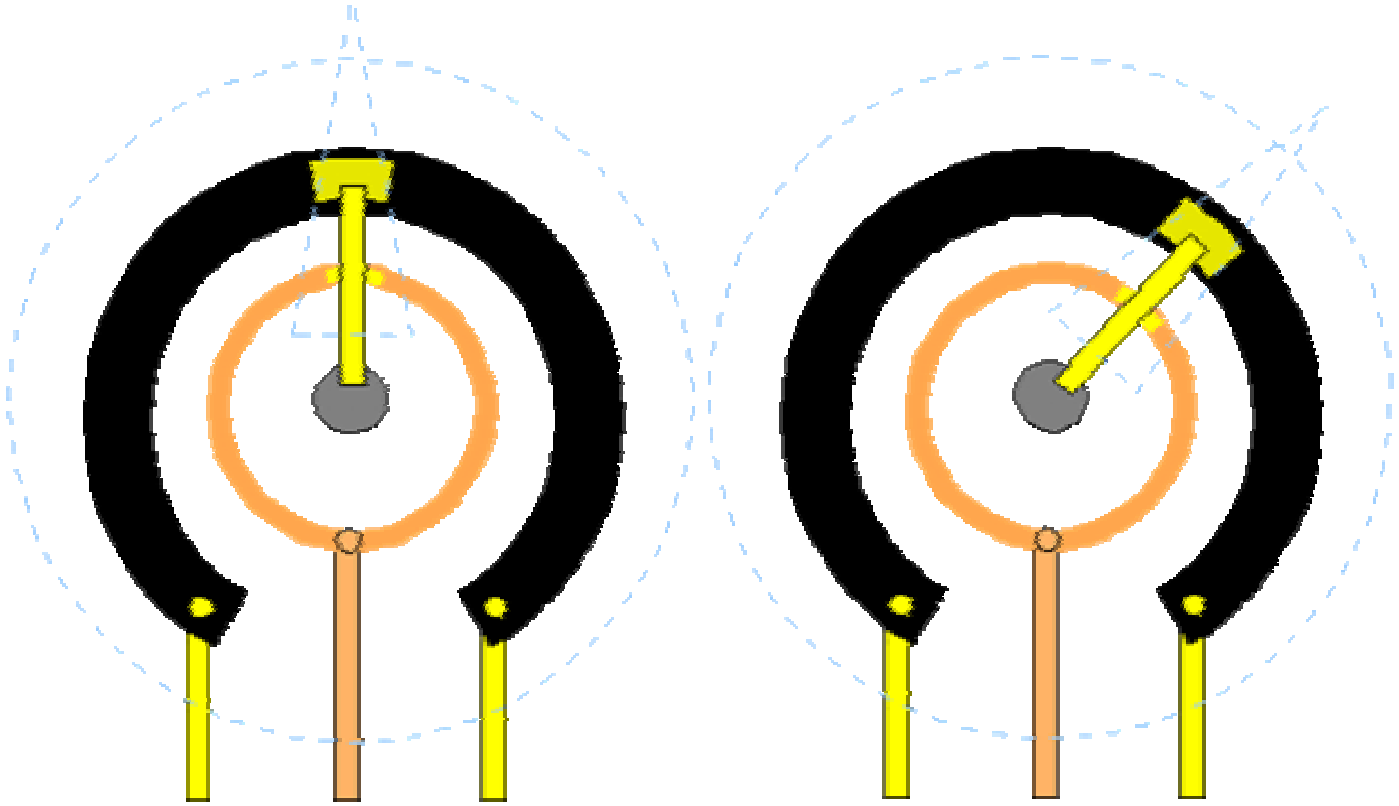
Exercise 2



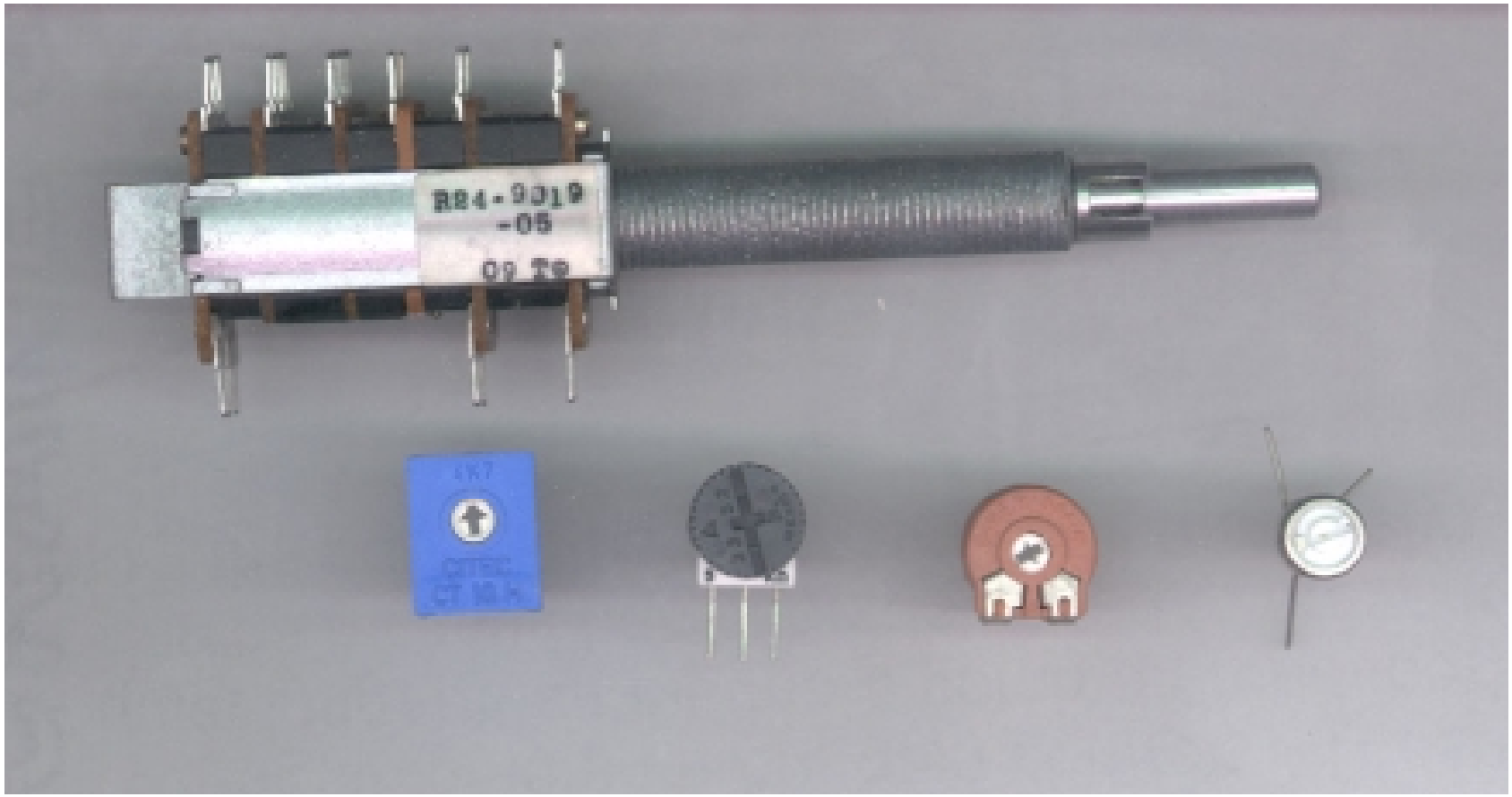
Potentiometer 1

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

Potentiometer 2

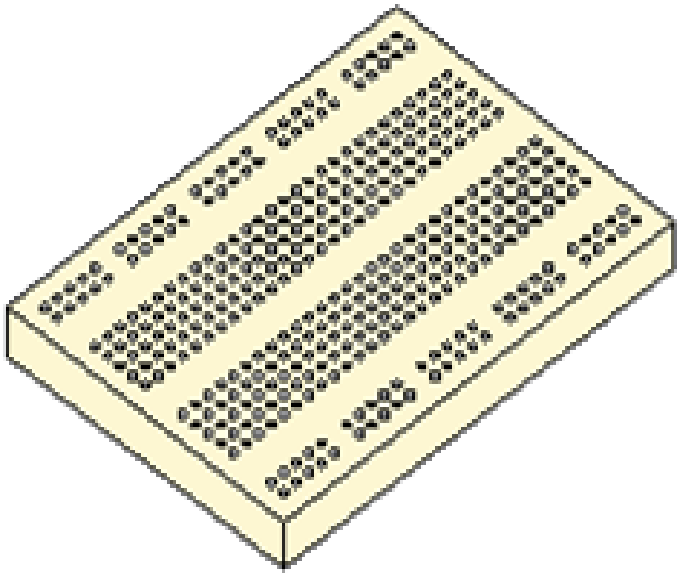


Rotary Potentiometers



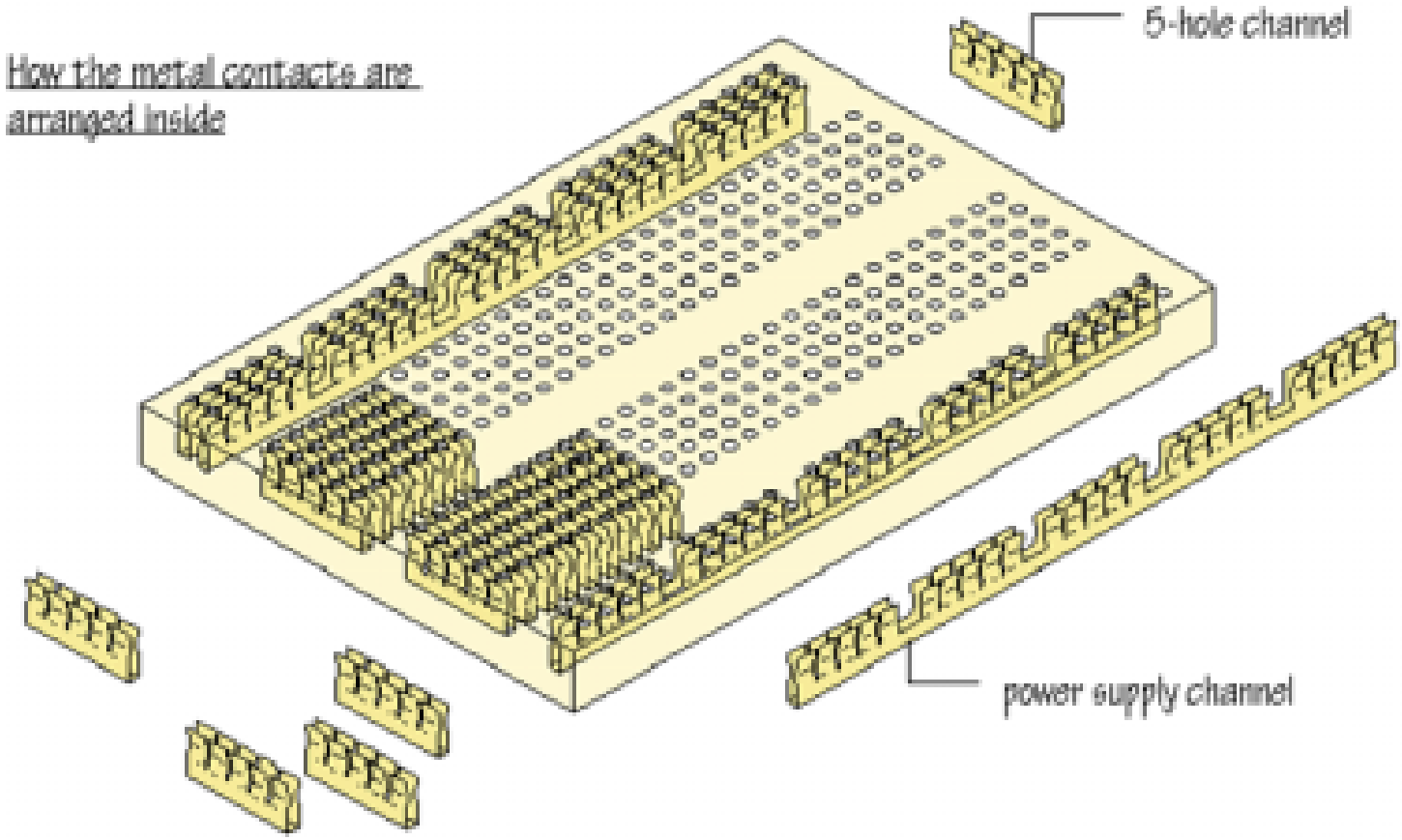
Linear Potentiometer

Breadboard 1

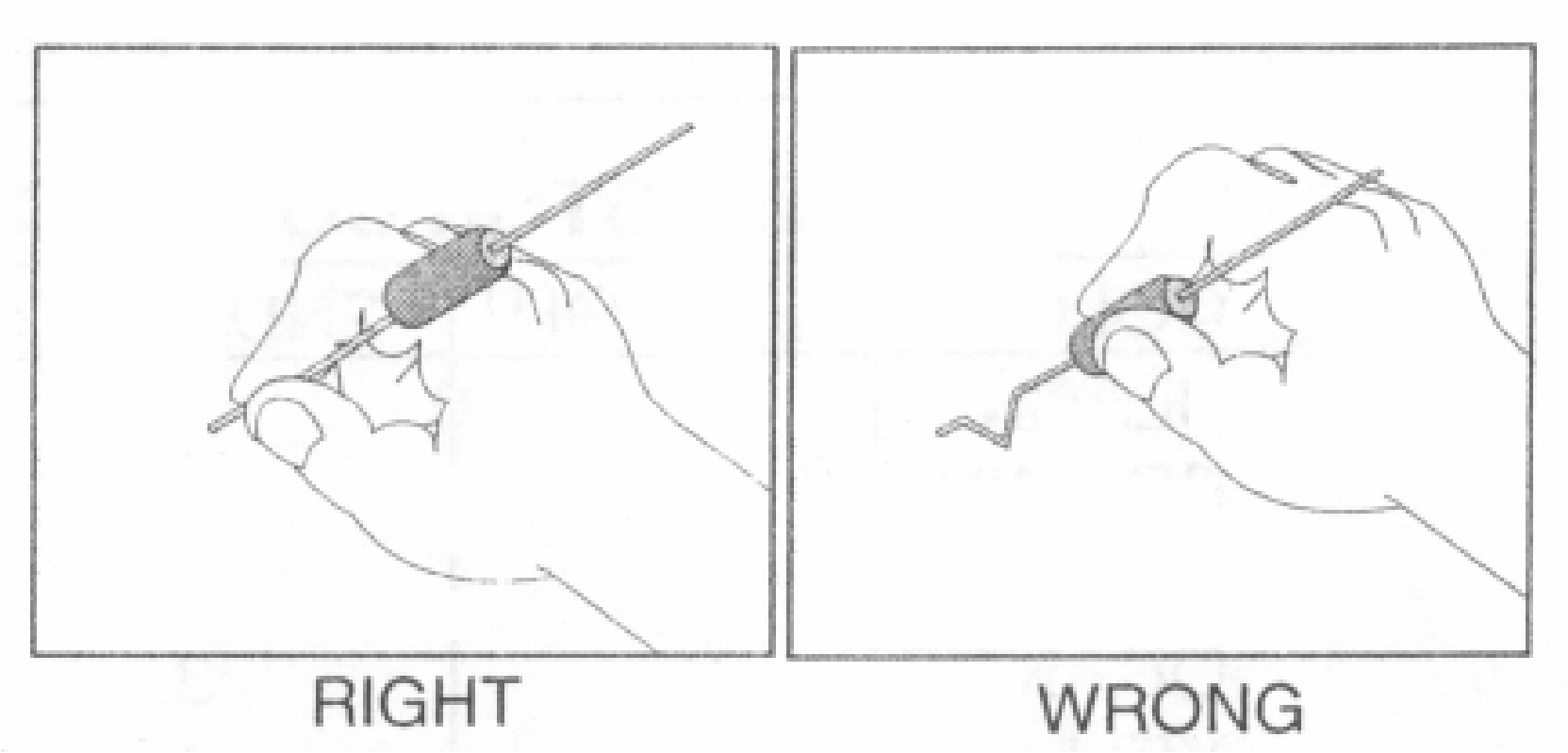


Prototype board is used for building temporary circuits, without soldering. Component leads are pushed into the holes in the board to make connections.

Breadboard 2



How to Insert a Component into a Breadboard



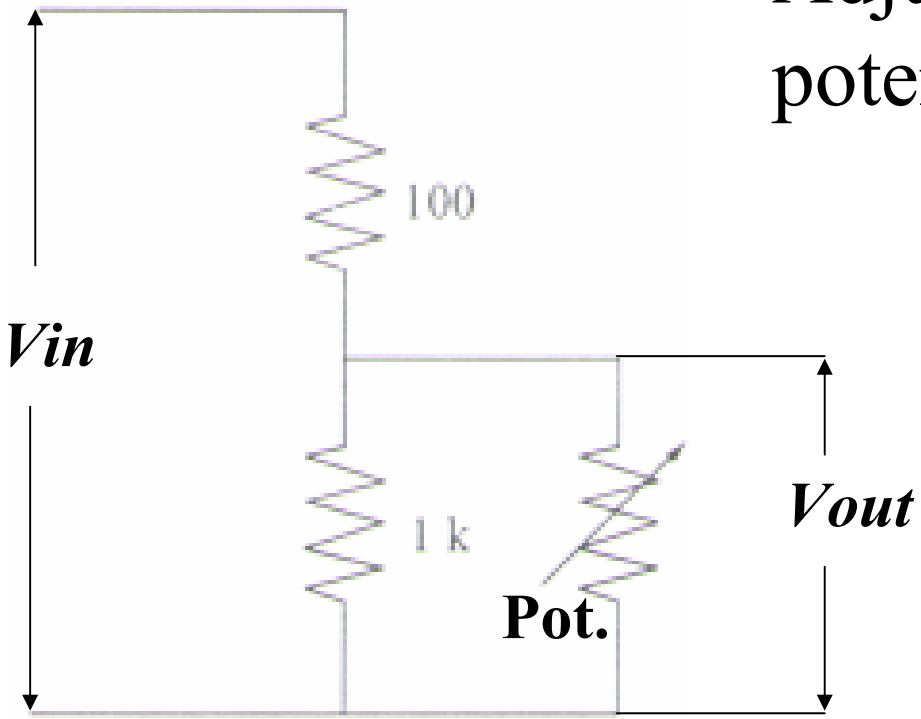
Resistor Experiments

Experiments	Chapters
What's micro controller	
Basic A and D	
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

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