Electrical Science: 2021-22
Lecture 2
Basic Electrical Quantities and Resistance

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Basic Electrical Quantities

- **Four quantities?**
  - Charge (C)
  - Current (Amps)
  - Voltage (Volts)
  - Power (Watt)

- **Charge**
  - Unit?
    - Coulomb (C)
    - SI unit
  - Charge of an electron?C
    - $q = -1.6 \times 10^{-19}$ C
    - How many electrons with 1C charge?
    - $1\ C = 1/1.6 \times 10^{-19}$ electrons
    - 6.25×10^{18} electrons

Basic Electrical Quantities

- Current
  - Time rate of change of electric charge
  - $I = dq/dt$
  - *Unit ?*
    - *Ampere (SI)*
  - 1 Amp = 1 Coulomb/sec
  - Types of current?
    - DC current
      - ❑ batteries
    - AC current
      - ❑ household current which varies with time

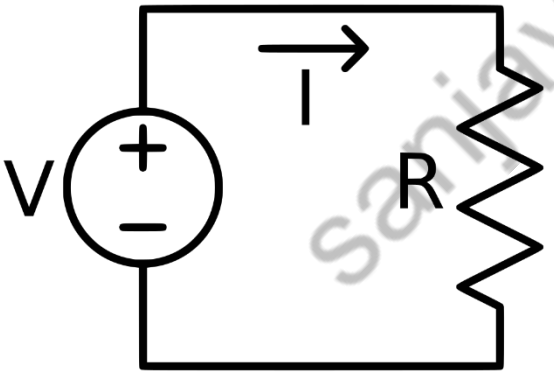
Basic Electrical Quantities

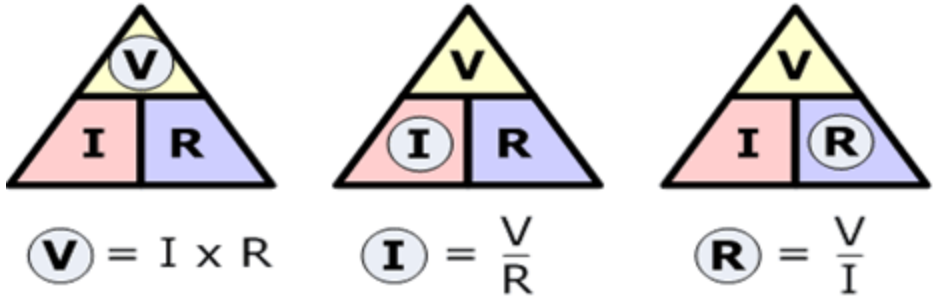
- **Voltage**
  - Energy required to move a unit charge through an element
  - Electromotive force or potential
  - Unit ?
    - Volt

- **Power**
  - P = I×V
  - Unit?
    - Watt
  - 1 Watt = 1 Volt·Amp = 1 Joule/sec

Resistors

- *Resistance* - The capacity of a material to impede flow of electric charge.
- The circuit element used to model this behavior is *resistor.*
- Resistance is measured in Ohms (Ω)

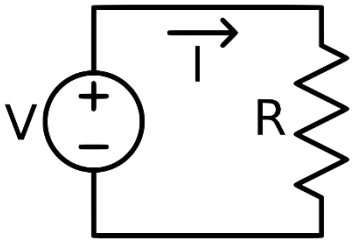


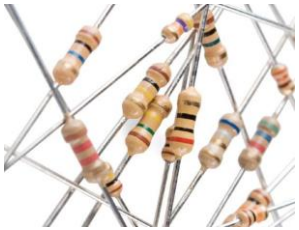


Ohms Law

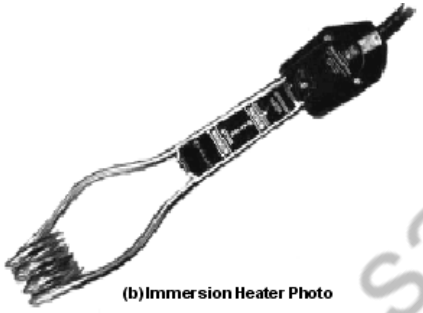
Resistors

- Power Dissipated as heat $P = VI = V^2/R = I^2R$



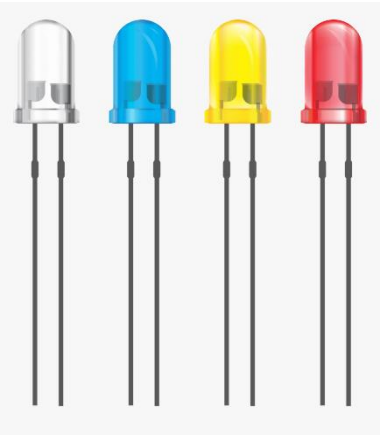


- Real-world devices that are modeled by resistors:
  - heating elements (stoves, heaters, etc.)
  - long wires
- Conductance $G = 1/R$ mho

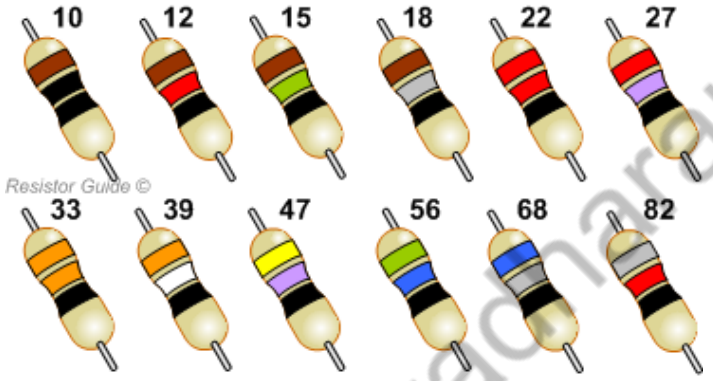


(b) Immersion Heater Photo

Fig. 3.4: Immersion Heater



Resistors



In 1952, the IEC (International Electrotechnical Commission) decided to define the resistance and tolerance values into a norm, to ease the mass manufacturing of resistors. These are referred to as "preferred values" or "E-series", and they are published in standard IEC 60063:1963.

very decade (0.1-1.0, 1-10, 10-100, etc.) is divided in 12 steps on a logarithmic scale.

The size of every step is equal to: $10^{(1/12)} = 1.21$

Resistors

Color	Value	Multiplier	Tolerance
Black	0	$\times 10^{0}$	± 20%
Brown	1	$\times 10^{1}$	± 1%
Red	2	$\times 10^{2}$	± 2%
Orange	3	$\times 10^{3}$	± 3%
Yellow	4	$\times 10^{4}$	- 0, + 100%
Green	5	$\times 10^{5}$	± 0.5%
Blue	6	$\times 10^{6}$	± 0.25%
Violet	7	$\times 10^{7}$	± 0.10%
Gray	8	$\times 10^{8}$	± 0.05%
White	9	$\times 10^{9}$	± 10%
Gold	–	$\times 10^{-1}$	± 5%
Silver	–	$\times 10^{-2}$	± 10%

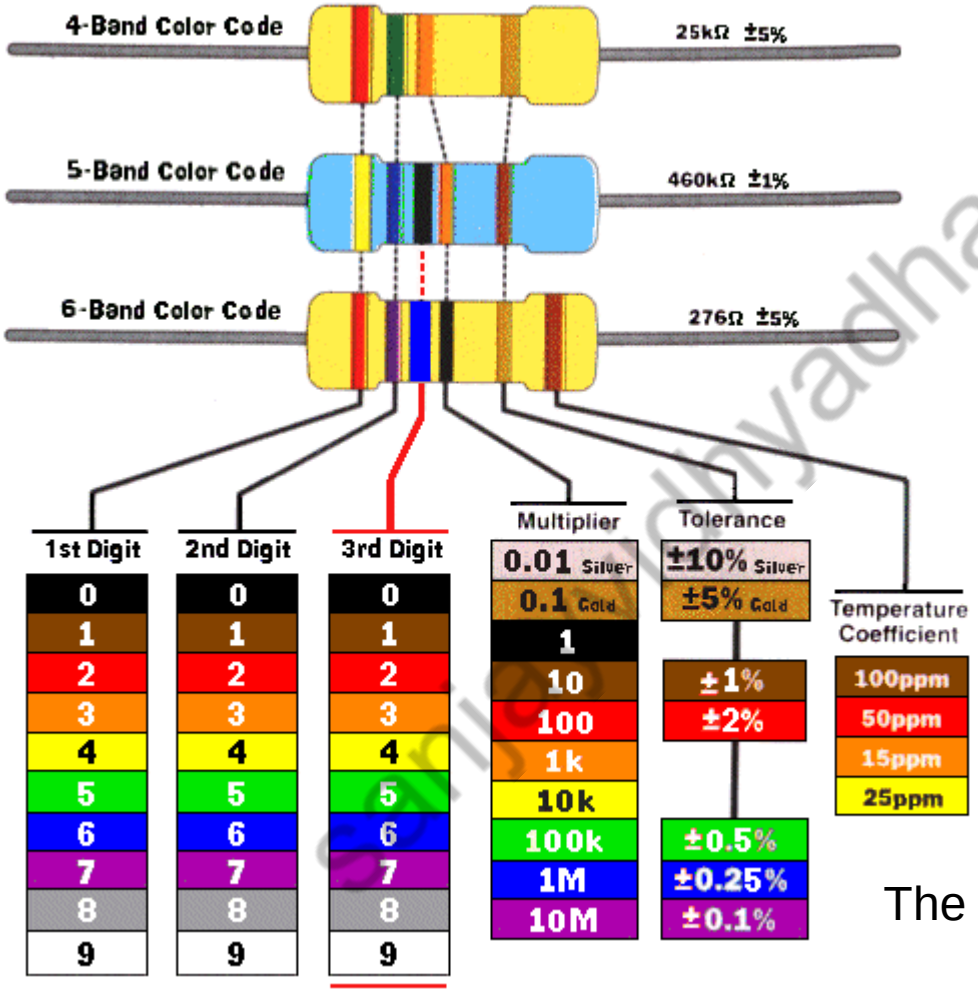
4-band resistor

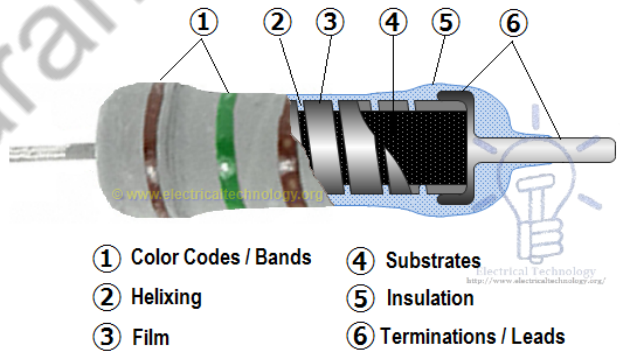
270 ohms ± 5%

5-band resistor

100k ohms ± 1%

Resistors

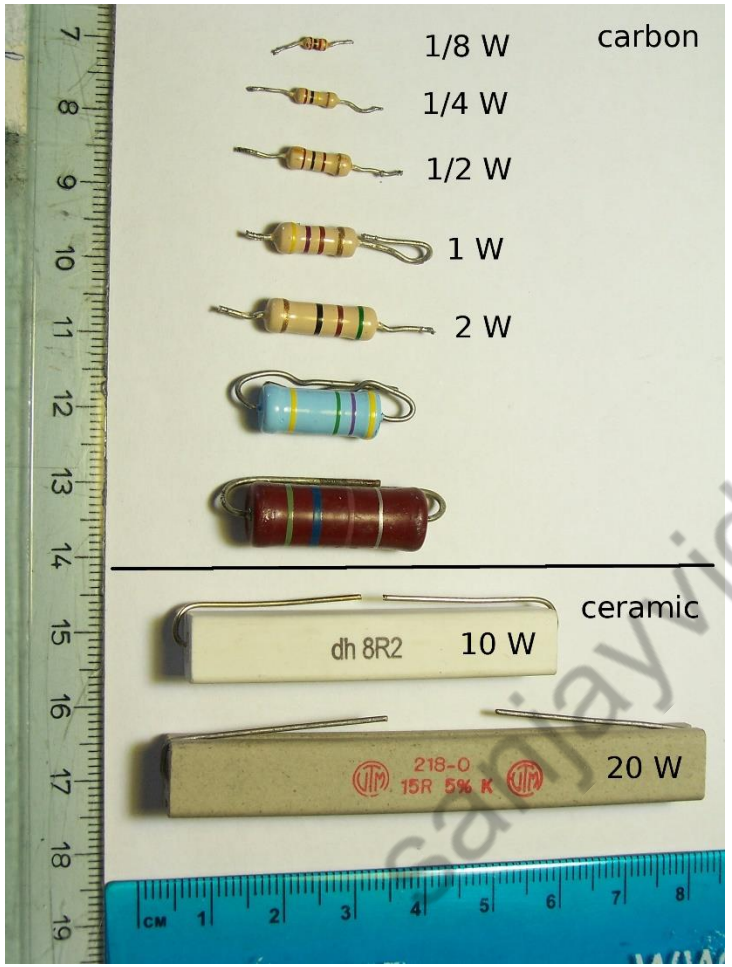




Carbon Film Resistors

The temperature coefficient (ppm/K)

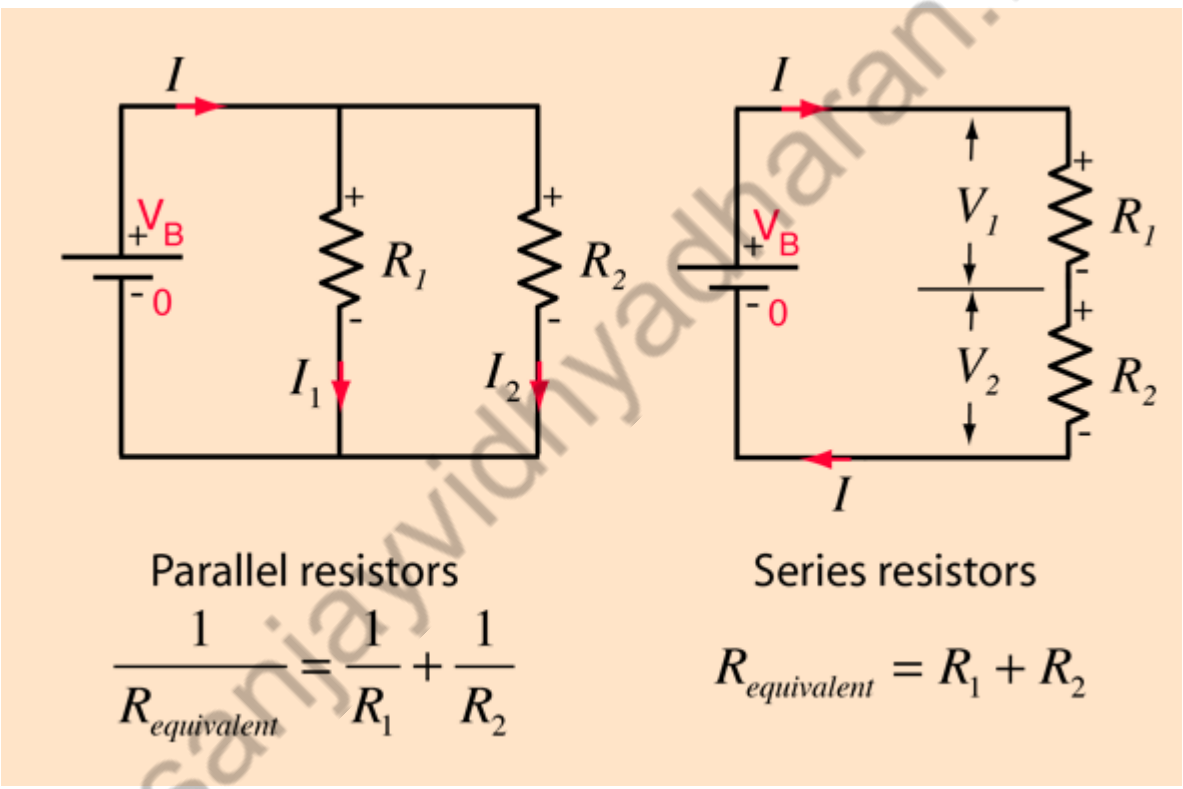
Resistors



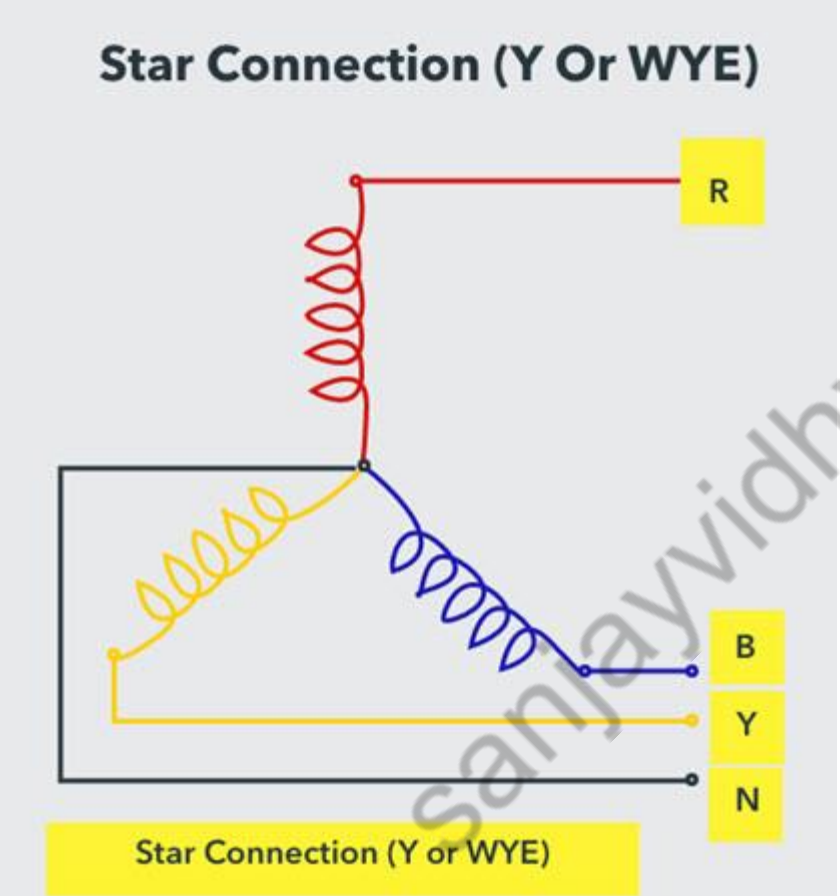
Resistors

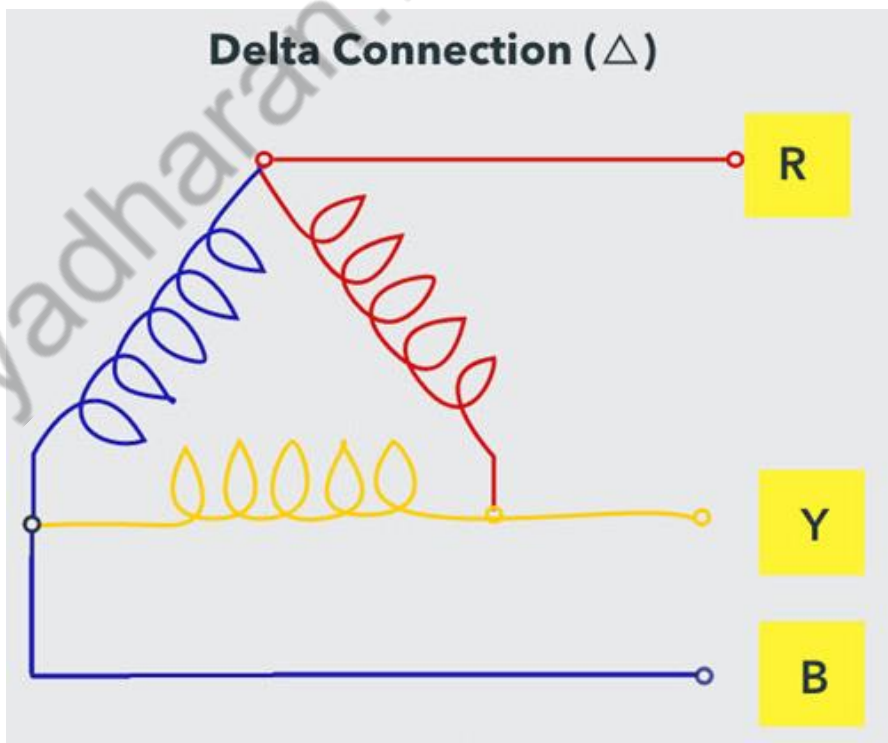
- **Potentiometers**

Resistors



Star and Delta Connections





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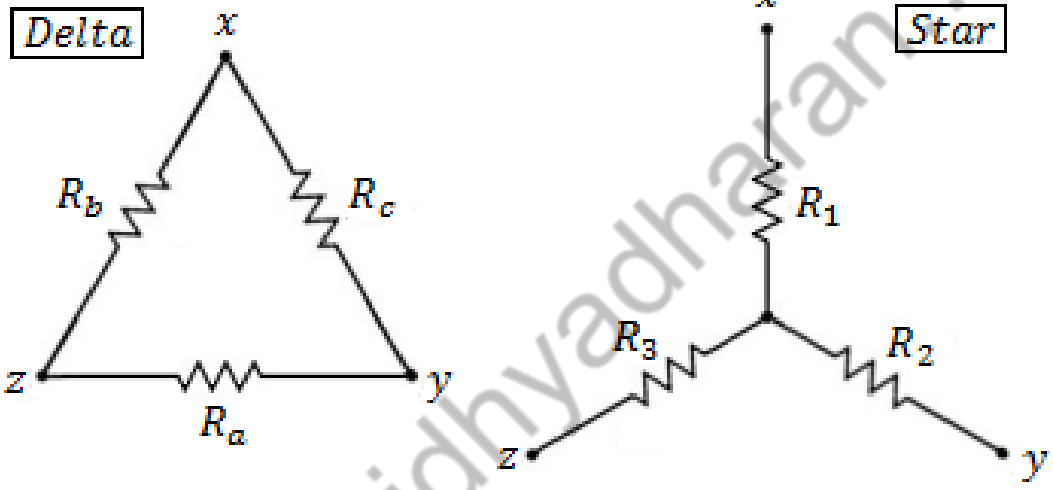


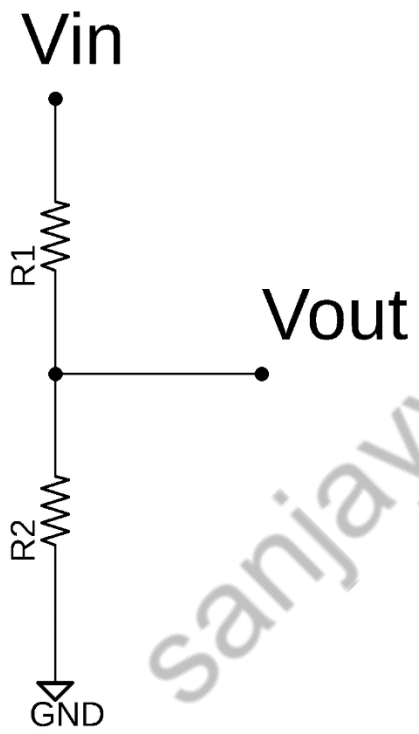
$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} \qquad R_1 = \frac{R_bR_c}{R_a + R_b + R_c}$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} \qquad R_2 = \frac{R_aR_c}{R_a + R_b + R_c}$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} \qquad R_3 = \frac{R_aR_b}{R_a + R_b + R_c}$$

Resistors

- **Applications**

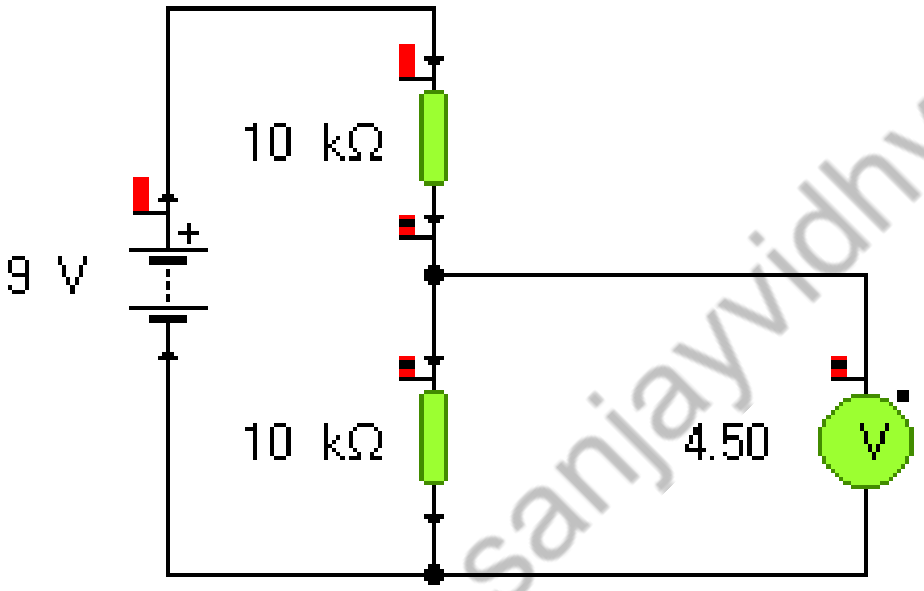


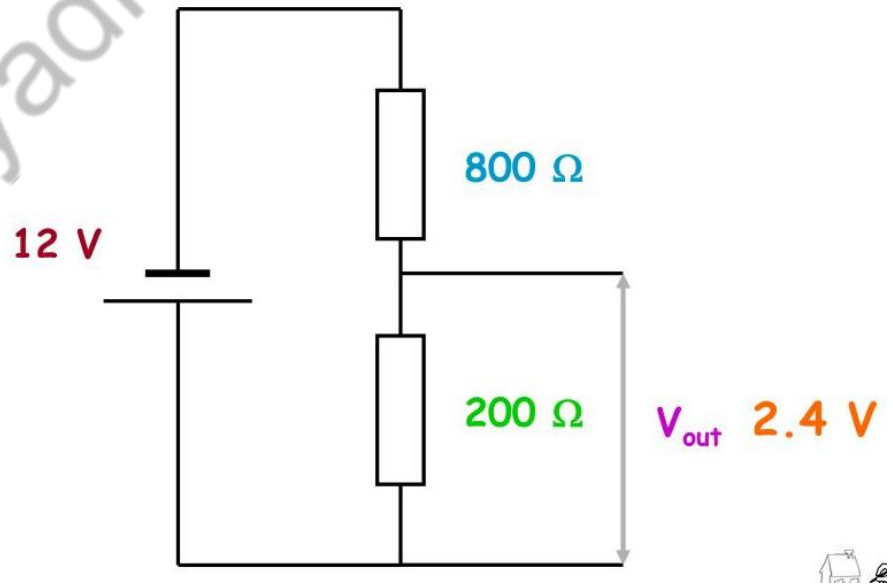
Voltage/Potential Divider

$$Vout = \frac{R2}{R1 + R2} Vin$$

Resistors

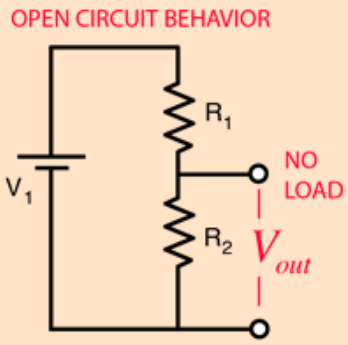
- **Applications**

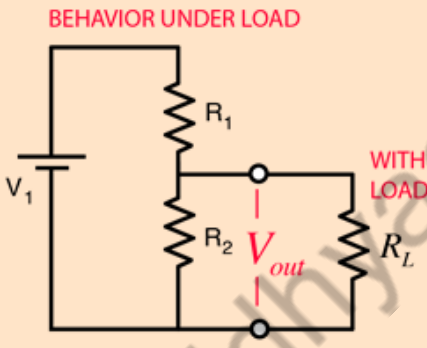




Resistors

- **Applications**





$$V_{out} = V_1 \frac{IR_2}{I(R_1 + R_2)} = \frac{V_1 R_2}{(R_1 + R_2)}$$

OUTPUT VOLTAGE UNDER "NO LOAD" CONDITION (open circuit)

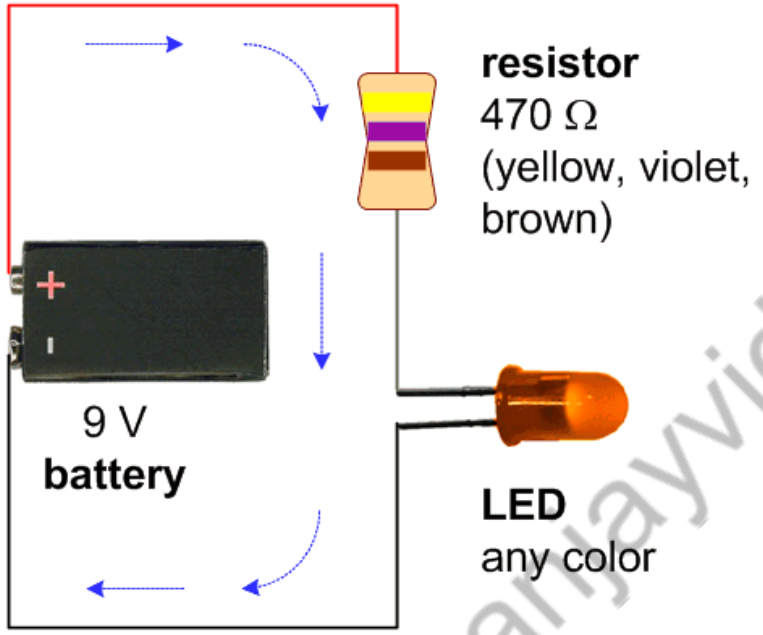
OUTPUT VOLTAGE UNDER LOAD

$$V_{out} = V_1 \frac{IR_2}{I(R_1 + R_2)} = \frac{V_1 (R_2 \parallel R_L)}{(R_1 + R_2 \parallel R_L)}$$

Voltage division concept is used in making radios, amplifiers and electronic devices for adjusting signal levels.

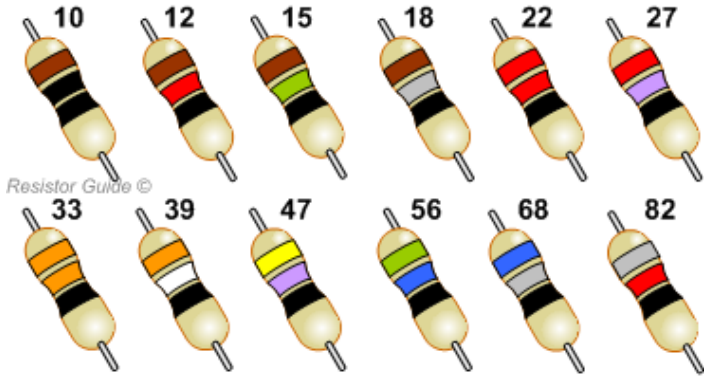
Resistors

- **Applications**



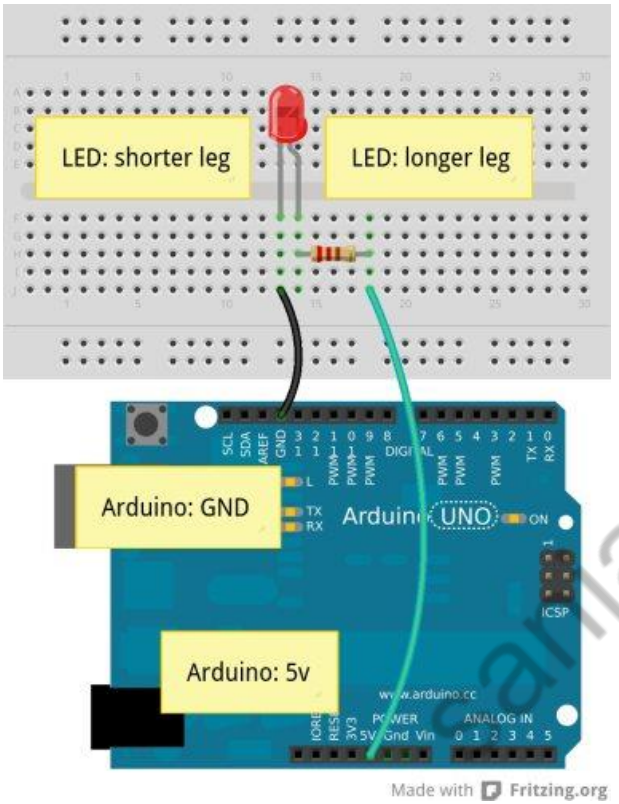
3mm Round LEDs (Water Clear)		Forward voltage		Dominant wavelength		Luminous Intensity		Viewing angle
Part number	Emitting Color	(V) IF=20mA		IF=20mA		(mcd) IF=20mA		
		TYP	MAX	MIN	MAX	TYP	MAX	(degree)
LED-WR3MMR	Red	1.8	2.3	620	640	2000	3000	20-30
LED-WR3MMY	Yellow	1.8	2.3	585	595	2000	3000	20-30
LED-WR3MMB	Blue	3.2	3.4	465	475	3000	5000	20-30
LED-WR3MMG	Green	3.2	3.4	520	530	8000	9000	20-30
LED-WR3MMW	White	3.2	3.4	/	/	8000	9000	20-30

$$R = \frac{9-1.8}{.02} = 360$$



Resistors

- **Applications**



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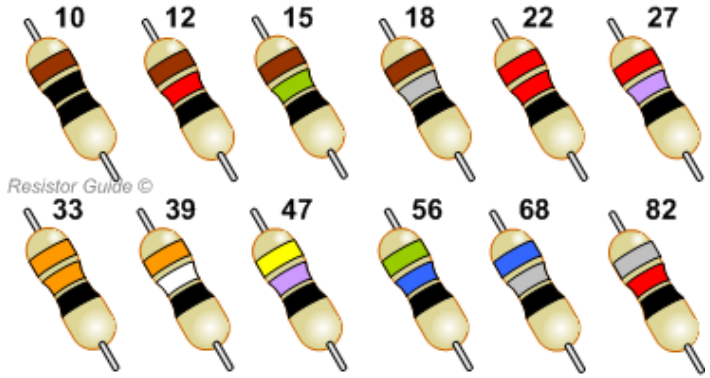
LED-WR3MMG	Green	3.2	3.4	520	530	8000	9000	20-30
LED-WR3MMW	White	3.2	3.4	/	/	8000	9000	20-30

$$R = \frac{5-1.8}{.02} = 160$$



Thank you