Simple DC Circuit:

DC: direct current… voltages and currents do not change with time

AC: alternating current… voltages and currents do change with time

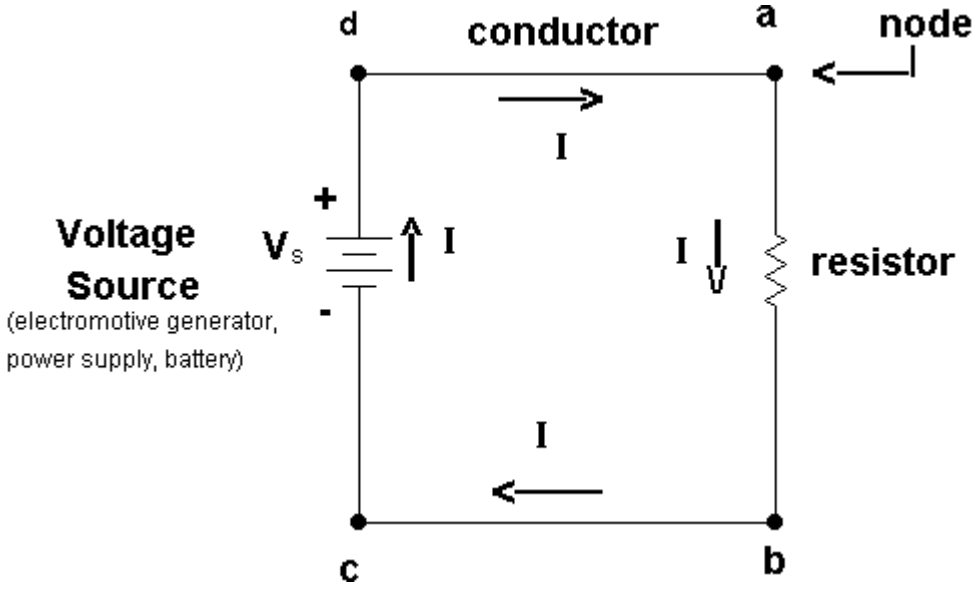
Simple DC Circuit Elements:

voltage source – ideal voltage source provides potential difference between two points (+ and - terminals) independent of current drawn. eg battery, power supply, "electromotive generator" (reality: all voltage sources have effective internal resistance which limits the current that can be drawn)

conductor – ideally element with zero resistance, wires a close approximation

node – point in circuit

resistor – current flow through ideal resistor is proportional to the voltage drop or potential difference across resistor (Ohm's Law)



Ohm's Law: V = I × R

Generally a property of conductors and resistors.

Not all materials or devices obey this 'law'.

$1\Omega = 1V/A = 1\ J \cdot s/C^2$

Power Dissipated in Conductor: P = I × V

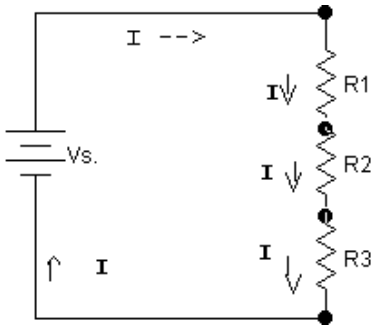
SI unit of power: Watt = $A \cdot V = C/s \cdot J/C = J/s$

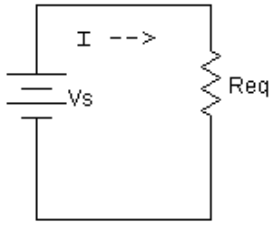
for materials obeying Ohm's Law: $P = I^2 R = V^2 / R$

Resistors in Series:

Same current, I, through all resistors

$V_s = I\,\mathbf{R_1} + I\,\mathbf{R_2} + I\,\mathbf{R_3} = \mathbf{I\,(R_1 + R_2 + R_3)}$ $\qquad V_s = I\,\mathbf{R_{eq}}$





$$\mathbf{R_{eq} = R_1 + R_2 + R_3}$$

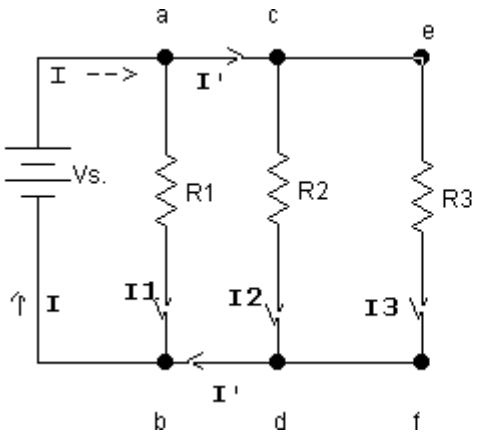
Resistors in Parallel:

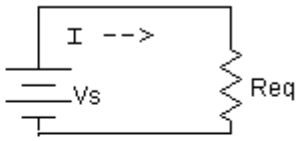
Voltage is the same across all three resistors

$Vs = Vab = Vcd = Vef$ $\qquad I = I_1 + I_2 + I_3$

$= I_1\,\mathbf{R_1} = I_2\,\mathbf{R_2} = I_3\,\mathbf{R_3}$

$$\mathbf{Vs/R_{eq} = Vs/R_1 + Vs/R_2 + Vs/R_3}$$





$$\mathbf{1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3}$$

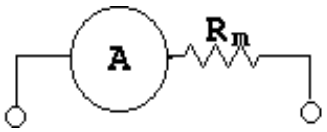
Analog Meters

Moving coil analog meter based on $\vec{F} = q\vec{v} \times \vec{B}$

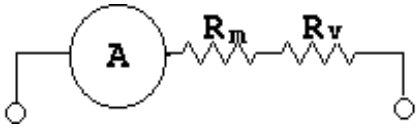
Deflection $\propto$ Current

Full ranges 1μA to 1mA are common; Accuracy typically 5%

Equivalent meter: includes the current measuring device (ammeter) in series with a resistor R_m.

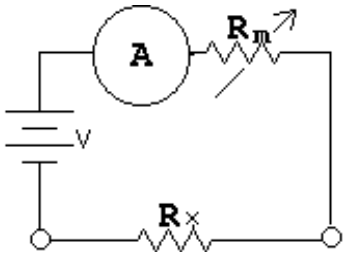


This can be used as a Voltmeter by adding a large R_v resistor in series with the meter resistor R_m : $R_v >> R_m$



(Question: what is the voltage across the two terminals in terms of the measured current I and the two resistors?)

A simple Ohm meter can be made by connecting the meter across a voltage source, putting an unknown resistor, R_x in series with the meter and measuring the current:



(Question: what is R_x in terms of the measured current I, the constant voltage and the variable meter resistor?)

DIGITAL MULTIMETER

Based on Analog to Digital Converter (ADC)… will learn how these work later in course.

Basic ADC digitizes voltage levels.

Adding a resistor in parallel with the input of the ADC converts it to an ammeter.

Adding a current supply and a resistor in parallel converts it to an Ohm meter.

DMM Specifications:

- One $^1/_2$ digit is used for the sign:
- No. of digits (eg $3^1/_2$: 1.999 ; $4^1/_2$: 1.9999; $6^1/_2$: 1.999999)
- Range: eg 200mV; 2V; 20V; 2000V
- Resolution: value of least significant digit
- Accuracy: low-end hand-held units: ±0.8% of reading + 0.2% of full scale
  typical $4^1/_2$ unit: ±0.6% of reading + 0.06% of full scale
- Input Impedance : same input impedance for all ranges, typically 1 to 10MΩ