Chapter 4

EMT1150
Introduction to Circuit Analysis

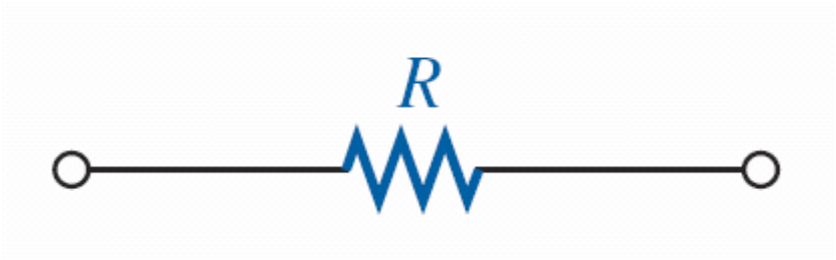
Department of Computer
Engineering Technology

Fall 2018

Prof. Rumana Hassin Syed

Review

- Resistance
- Unit Ohm, Ω
- Symbol
- Four factors



$$R = \rho \frac{l}{A}$$

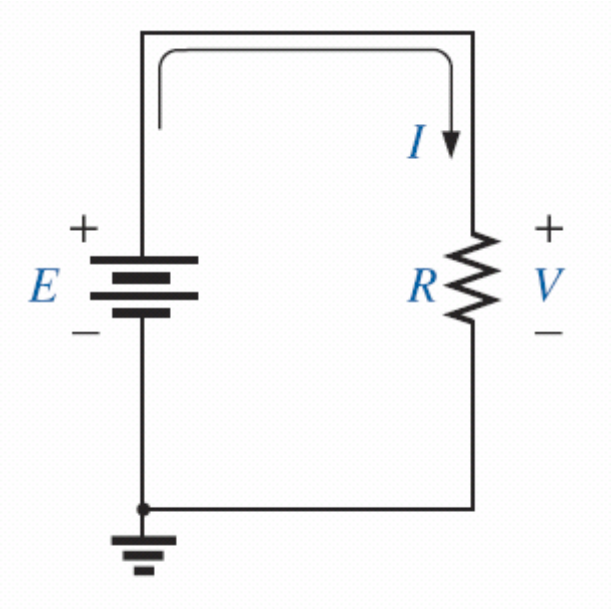
ρ : resistivity of the sample (Ω-centimeter at T=20° C)
l : the length of the sample (centimeter)
A : cross-sectional area of the sample (cm^2)

Chapter4 Ohm's Law, Power, Energy

- Introduction to Ohm's Law
- Plotting Ohm's Law
- Power
- Energy

Ohm's Law

- **Ohm's law** clearly reveals that a fixed resistance, the greater the voltage across a resistor, the more the current, the more the resistance for the same voltage, the less the current.



$$\text{Effect} = \frac{\text{cause}}{\text{opposition}}$$

Ohm's Law

- The potential difference, or voltage, between two points is the cause ("pressure").
- The opposition is the resistance encountered.
- Current is a reaction to the applied voltage.

$$I = \frac{V}{R}$$

$$I : amperes,\ A$$

$$V : Volt, V$$

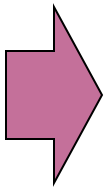
$$R : Ohm, \Omega$$

Ohm's Law

- Derivations

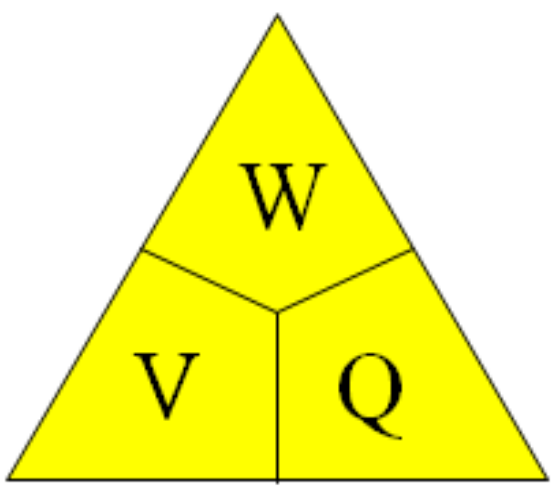
$$V = IR$$

$$I = \frac{V}{R}$$



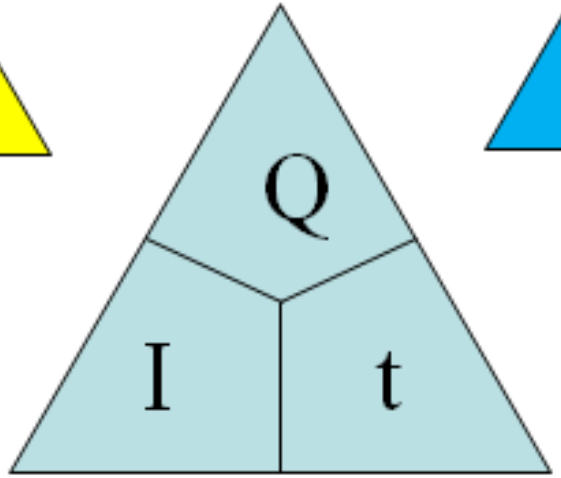
$$R = \frac{V}{I}$$

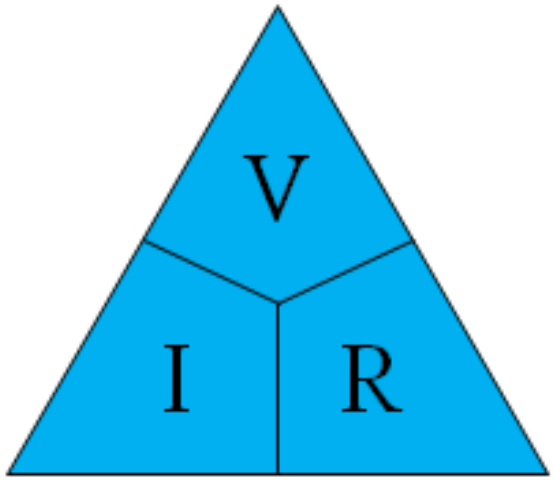
Laws to Remember:



Voltage

Current

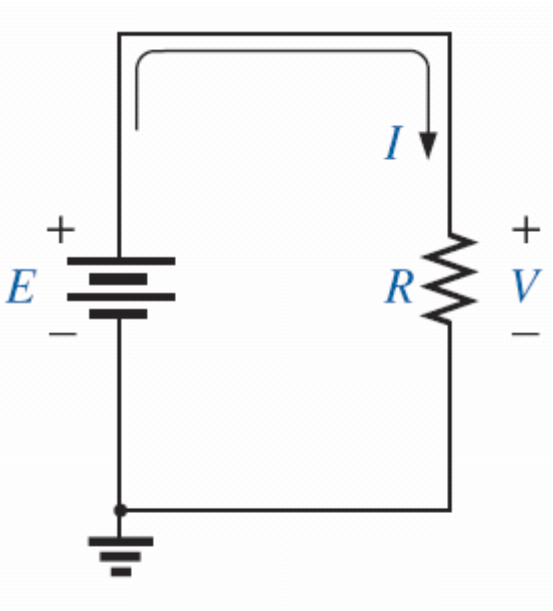




Ohm's Law

Exp1. Determine the current resulting from the application of a 9-V battery across a network with a resistance of 2.2 Ω.

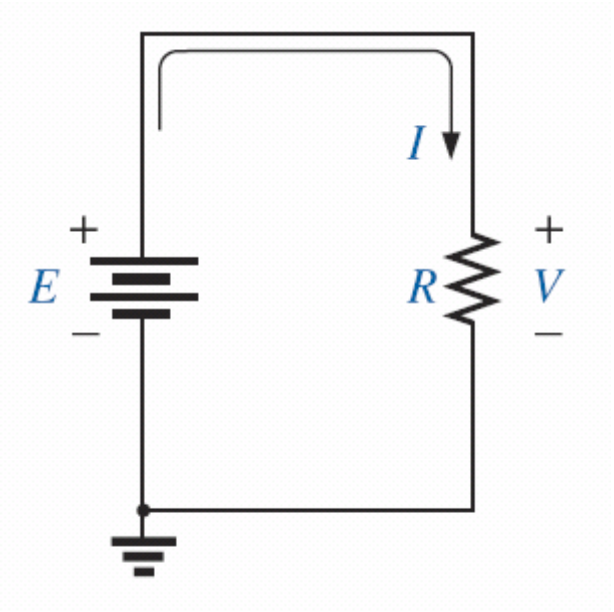
$$I = \frac{E}{R} = \frac{9V}{2.2\Omega} = 4.09(A)$$



Exp2. Calculate the resistance of a 60-W bulb if a current of 500 mA results from an applied voltage of 120 V.

$$R = \frac{E}{I} = \frac{120V}{500 \times 10^{-3} A} = 240(\Omega)$$

- E is used for all source of voltage.
- V is applied to all voltage drop across components of the network.

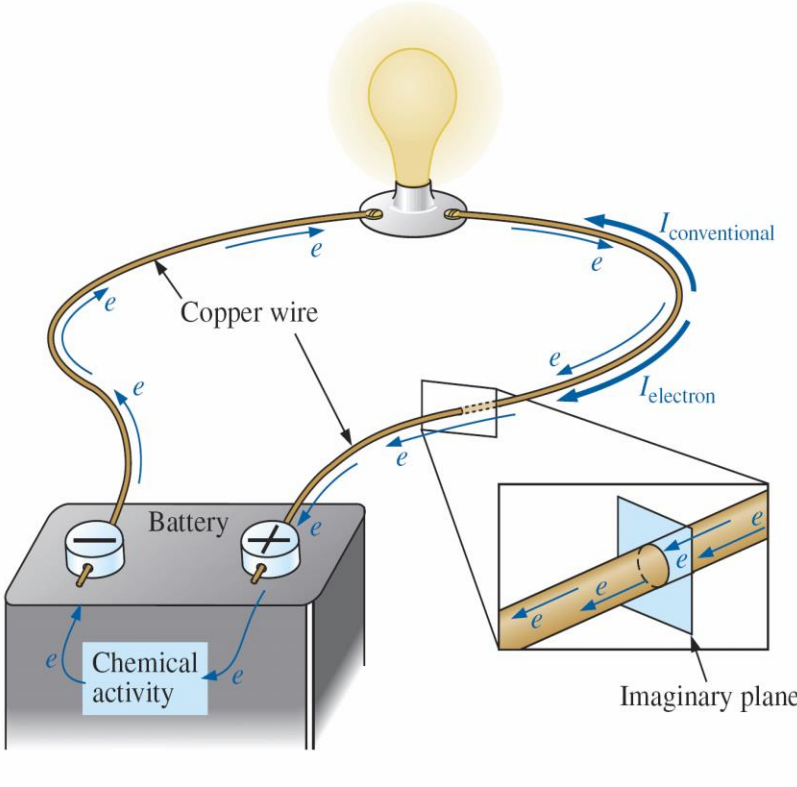


$$I = \frac{V}{R}$$

$$I = \frac{E}{R}$$

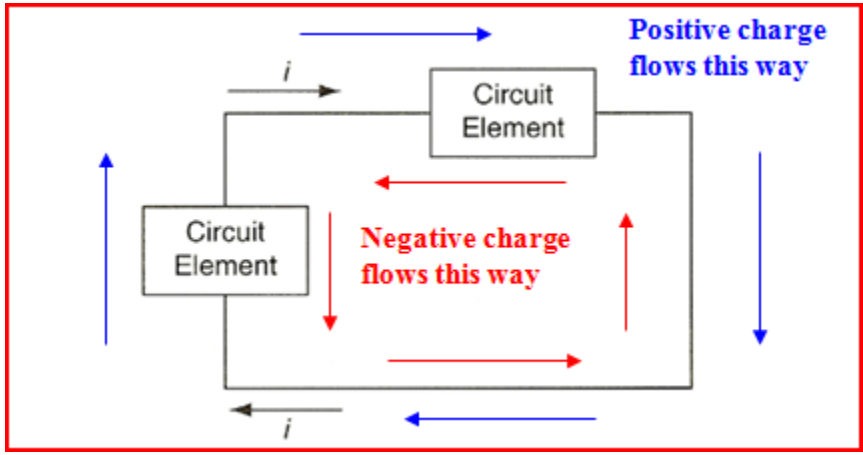
Ohm's Law

- Conventional flow: the moving direction of positive charge.
- Electron flow: the moving direction of electrons.

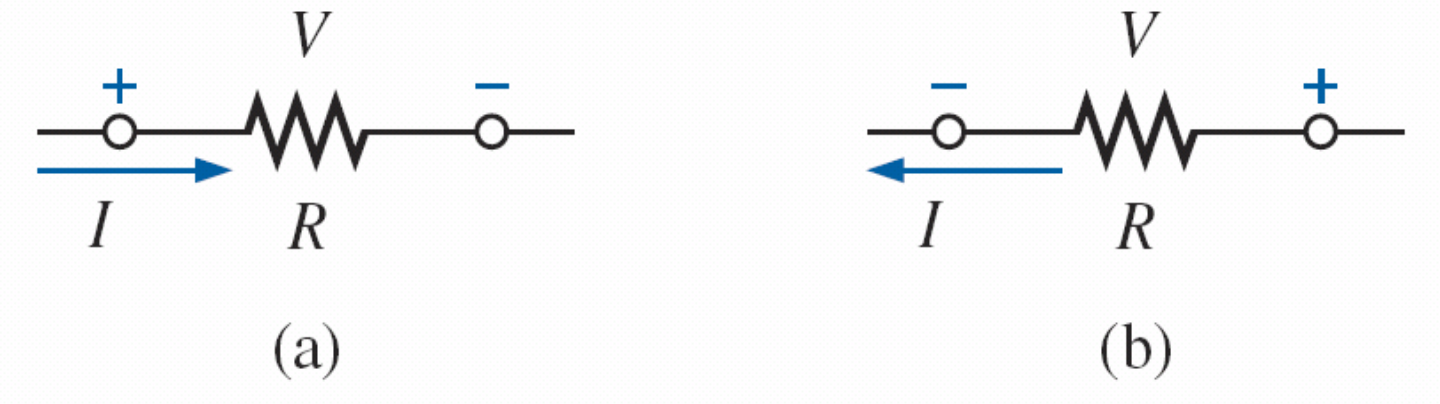


•Current is defined as positive if:

- a positive charge is moving in the direction of the arrow.
- a negative charge is moving in the opposite direction of the arrow.



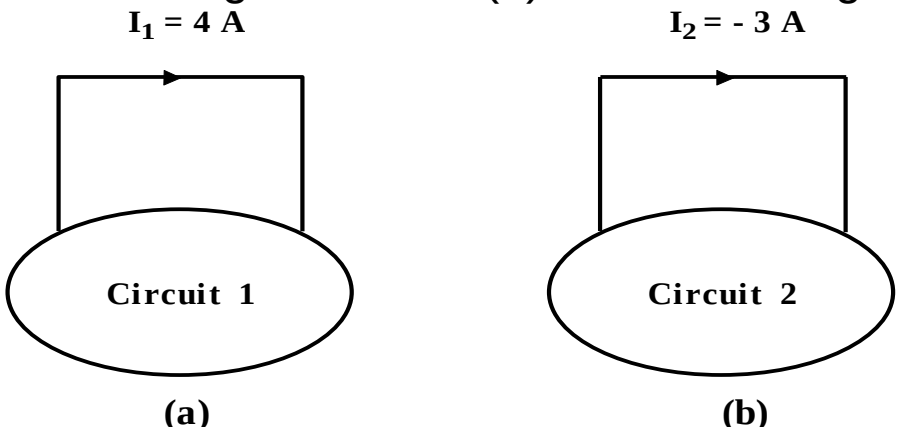
- For an isolated resistive element, the polarity of the voltage drop is as shown in figure(a) for the indicated current direction.
- A reversal in current will reverse the polarity, as shown in Fig.(b).



In general, the flow of current through a resistor is from a high potential (+) to a low potential (–).

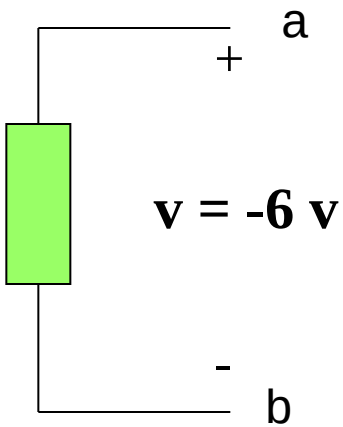
Checking Understanding

1. What is the actual direction of current in the circuit?
   A. From left to right in (a), from left to right in (b)
   B. From left to right in (a), from right to left in (b)
   C. From right to left in (a), from left to right in (b)
   D. From right to left in (a), from left to right in (b)



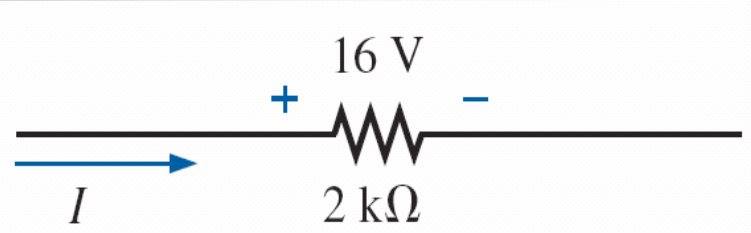
Answer: (B)

2. Which end has actual higher potential?



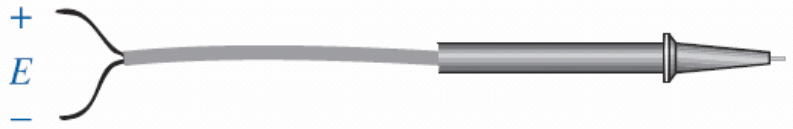
Answer: (b).
$V=V_+ - V_- = V_a - V_b = -6$ (V)
$V_b > V_a$

Exp3. Calculate the current through the 2 kΩ resistor if the voltage drop across it is 16 V.



$$I = \frac{V}{R} = \frac{16V}{2 \times 10^3 \Omega} = 8.0(mA)$$

Exp4. Calculate the voltage that must be applied across the soldering iron to establish a current of 1.5 A through the iron if its internal resistance is 80 Ω.

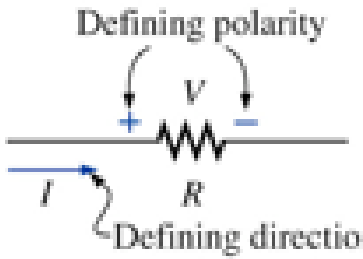


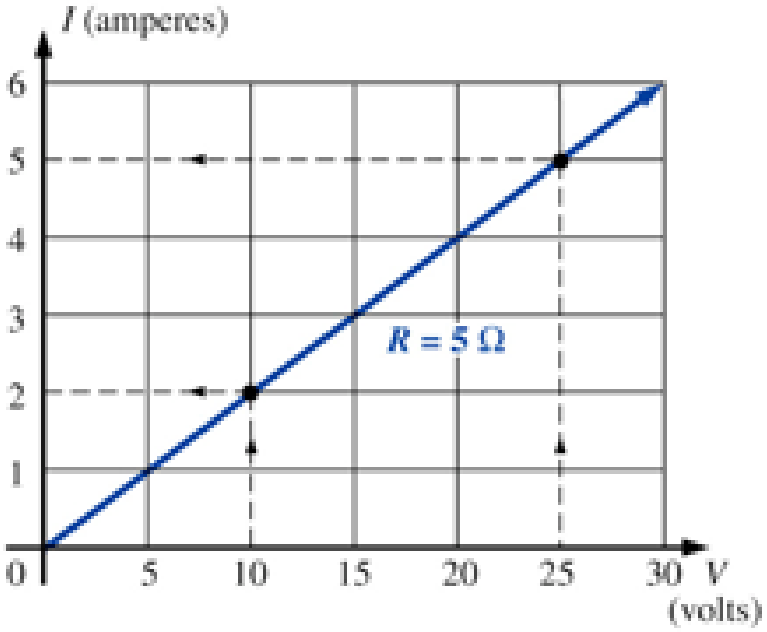
$$E = I \cdot R = (1.5\ A)(80\ \Omega) = 120\ V$$

Plotting Ohm's law

Graph, characteristics, plots play an important role in every technical field as a mode through which the broad picture of the behavior or response of a system can be conveniently displayed. It is therefore critical to develop the skills necessary both to read data and to plot them in such a manner that they can be interpreted easily.

For most sets of characteristics of electronic devices, the current is represented by the vertical axis, and the voltage by the horizontal axis.

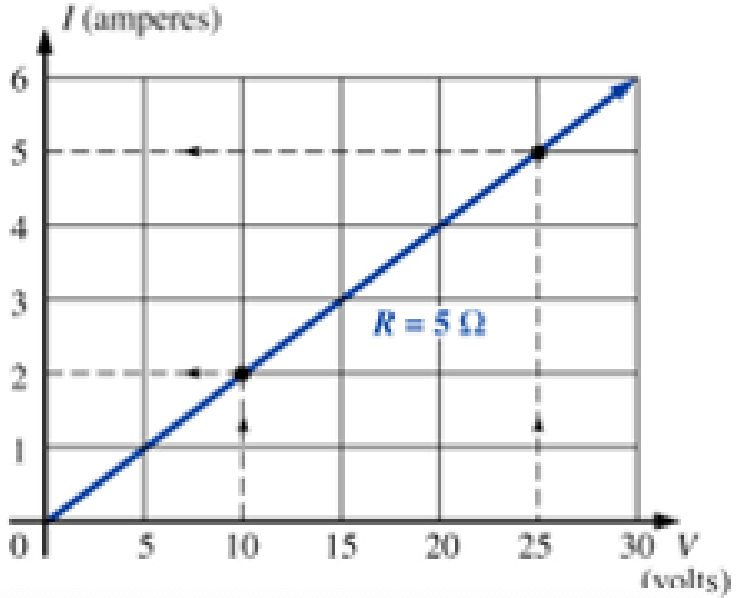




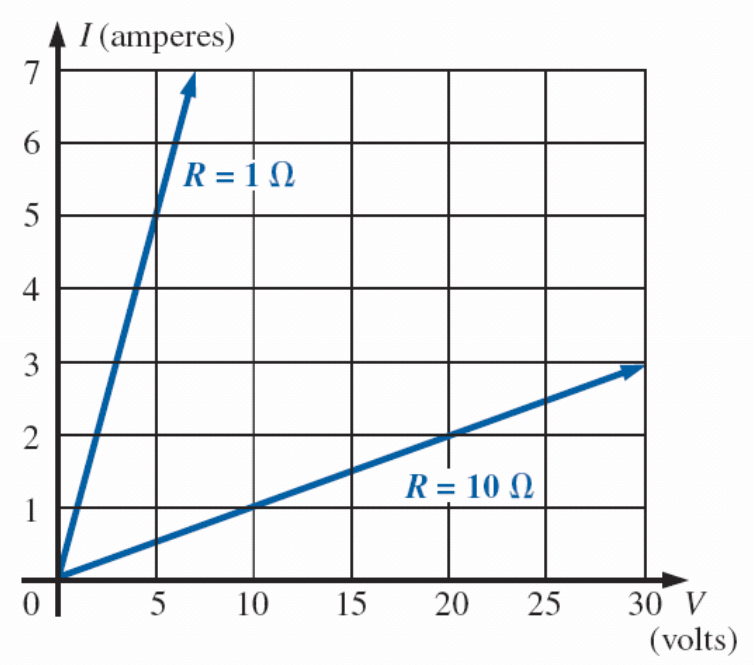
How to get resistance from graph?

$$I = \frac{1}{R} \cdot V + 0$$

$$y = m \cdot x + b$$



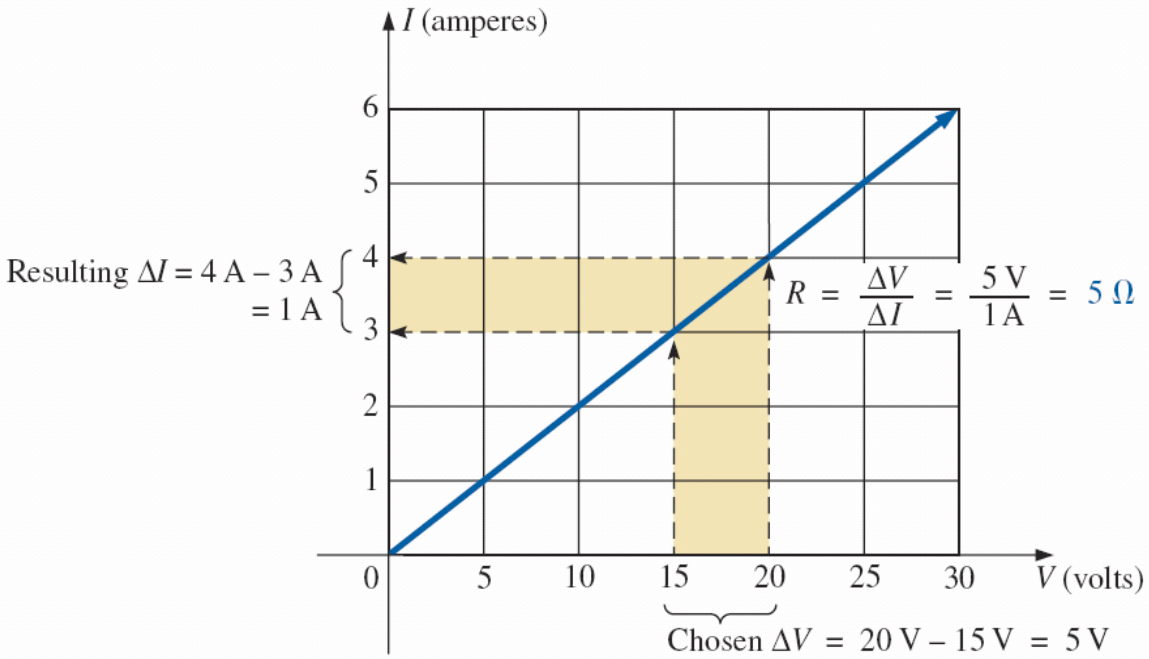
If the resistance of a plot is unknown, find the resulting current and voltage at any point on the plot, then apply the ohm's law.



$$m = slope = \frac{\Delta I}{\Delta V} = \frac{1}{R}$$

$$R = \frac{\Delta V}{\Delta I}$$

The equation states that by choosing a particular *ΔV* (or *ΔI*), one can obtain the corresponding *ΔI* (or *ΔV,* respectively)from the graph, and then determine the resistance.



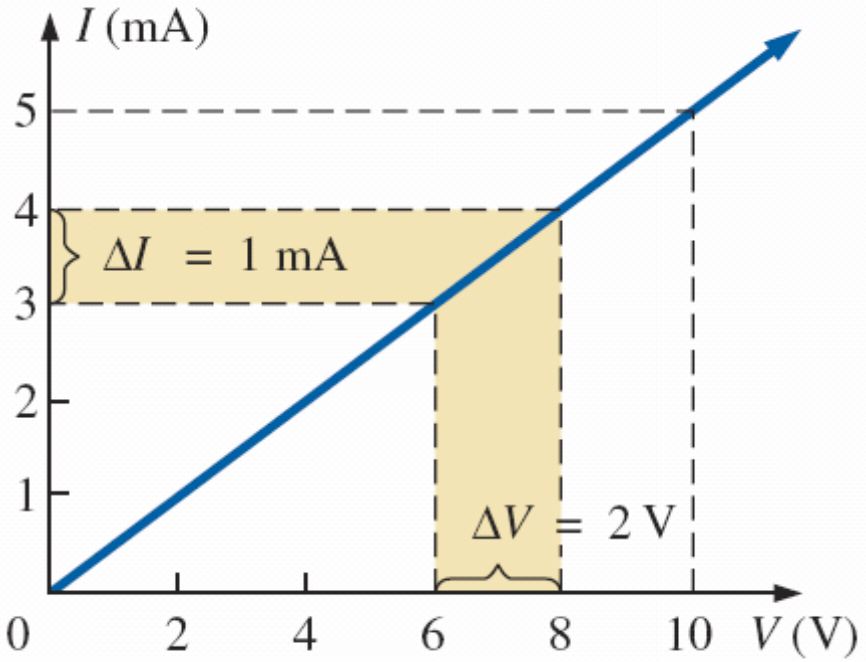
Exp6. Determine the resistance associated with the curve in the figure using equations from previous slides, and compare results.

At $V = 6\,V$, $I = 3\,mA$, *and*

$$R_{dc} = \frac{V}{I} = \frac{6\,V}{3\,mA} = 2\,k\Omega$$

At the int*erval between* $6\,V$ *and* $8\,V$,

$$R = \frac{\Delta V}{\Delta I} = \frac{2\,V}{1\,mA} = 2\,k\Omega$$



Power

- the term power is an indication of how much work can be accomplished in a specified amount of time.
- Power is a rate of doing work.

$$P = \frac{W}{t} \qquad (watts, W, or\ joules/\text{second}, J/s)$$

1 watt (W) = 1 joules/second (J/s)

1 horsepower ≈ 746 watts

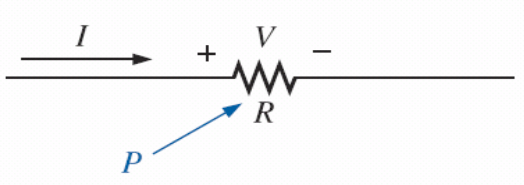
Power

- Relationship with Voltage and Current

$$P = \frac{W}{t} = \frac{Q \cdot V}{t} = V\frac{Q}{t} = V\,I\ (watts) \quad where\ I = \frac{Q}{t}$$

$$P = V \cdot I = V\left(\frac{V}{R}\right) = \frac{V^2}{R} \quad (watts)$$

$$P = V \cdot I = (I \cdot R)I = I^2 R \quad (watts)$$



The result is that the power absorbed by the resistor can be found directly depends on the information available.

Energy

- Energy is the ability of a system to perform work.

$$W = Pt$$

$$\text{P: Watt, W}$$

$$\text{t: second, s}$$

$$\text{W: Joules, or Ws}$$

- Define an electric equipment rated at 1000 watts (1 kilowatt), operating for one hour uses one kilowatt-hour (kWh)of energy.
- Electrical energy is sold in kilowatt-hours.