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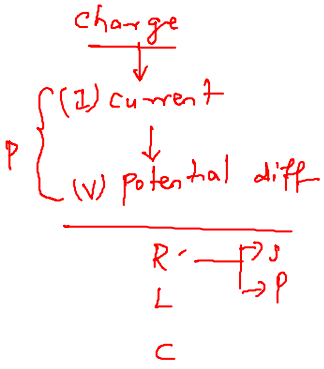
Unit - I
Introduction and Basic Concepts



Dr.Santhosh.T.K.

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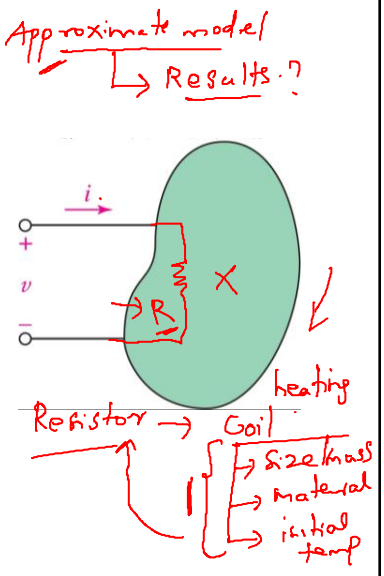
Circuit Elements

- A circuit element usually has two terminals (sometimes three or more).
- The relationship between the voltage *v* across the terminals and the current *i* through the device defines the circuit element model.



Abstraction

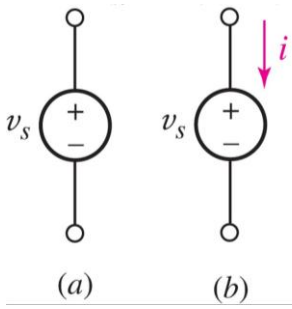
Linear Elements and Circuits

- a linear circuit element has a linear voltage-current relationship:
  - if $i(t)$ produces $v(t)$, then $Ki(t)$ produces $Kv(t)$
  - if $i_1(t)$ produces $v_1(t)$ and $i_2(t)$ produces $v_2(t)$, then $i_1(t) + i_2(t)$ produces $v_1(t) + v_2(t)$,
- resistors, sources are linear elements[1]
- a linear circuit is one with only linear elements

[1]Dependent sources need linear control equations to be linear elements.

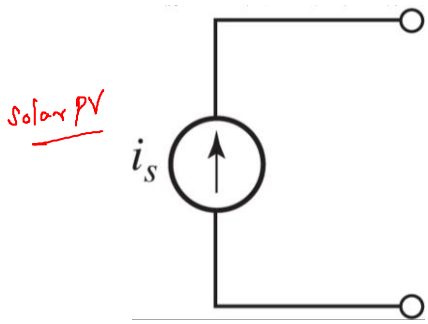
Voltage Sources

- An ideal voltage source is a circuit element that will maintain the specified voltage v_s across its terminals.
- The current will be determined by other circuit elements.



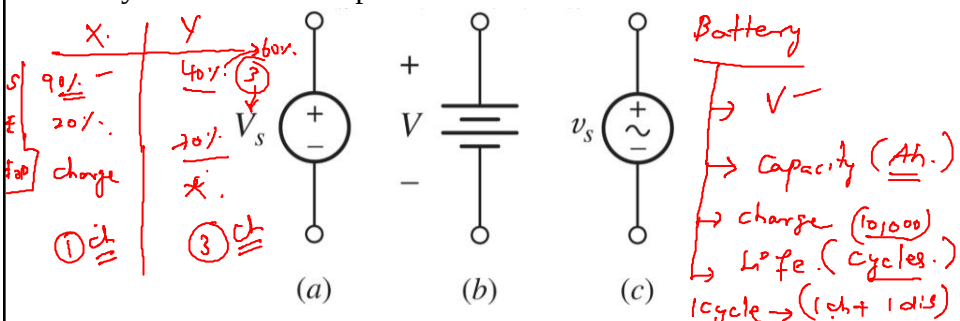
Current Sources

- An ideal current source is a circuit element that maintains the specified current flow i_s through its terminals.
- The voltage is determined by other circuit elements.



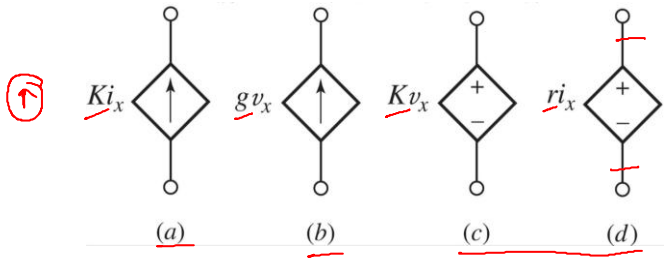
Battery as Voltage Source

- A voltage source is an idealization (no limit on current) and generalization (voltage can be time-varying) of a battery.
- A battery supplies a constant "dc" voltage V but in practice a battery has a maximum power.



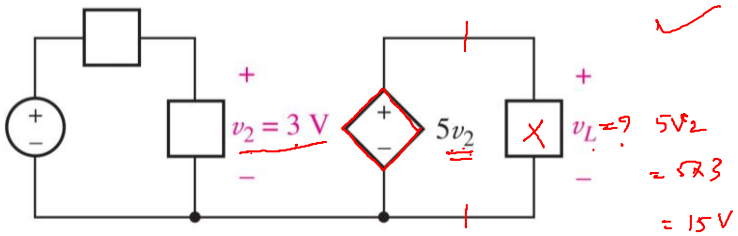
Dependent Sources

- Dependent current sources (a) and (b) maintain a *current* specified by another circuit variable.
- Dependent voltage sources (c) and (d) maintain a *voltage* specified by another circuit variable.



Example: Dependent Sources

Find the voltage v_L in the circuit below.

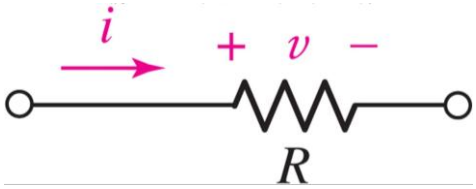


Ohm's Law: Resistance

- A (linear) resistor is an element for which

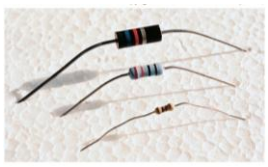
$$v=iR$$

- where the constant R is a resistance.
- The equation is known as "Ohm's Law."
- The unit of resistance is ohm (Ω).



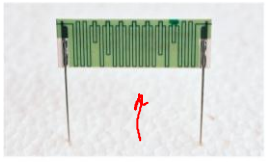
Resistors

(a) typical resistors (b) power resistor
(c) a 10 TΩ resistor (d) circuit symbol

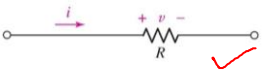


(a)

(b)



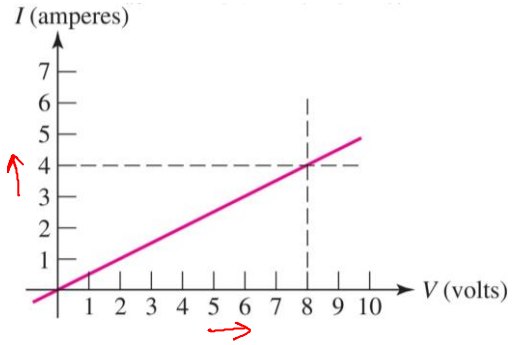
(c)



(d)

The i-v Graph for a Resistor

For a resistor, the plot of current versus voltage is a straight line:



In this example, the slope is 4 A / 8 V or 0.5 Ω^{-1}.

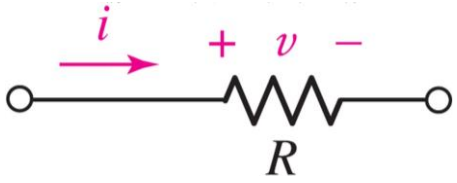
This is the graph for a 2 ohm resistor.

Power Absorption

Resistors absorb power: since $v=iR$

$$p=vi = v^2/R = i^2R$$

Positive power means the device is absorbing energy. Power is always positive for a resistor!



Example: Resistor Power

A 560 Ω resistor is connected to a circuit which causes a current of 42.4 mA to flow through it. Calculate the voltage across the resistor and the power it is dissipating.

$v = iR = (0.0424)(560) = 23.7$ V

$p = i^2R = (0.0424)^2(560) = 1.007$ W

$v = iR$ — (1)

$p = v \cdot i$ — (2)

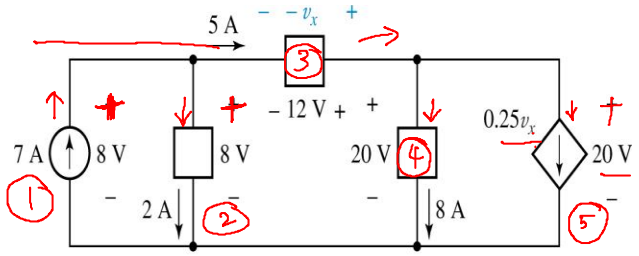
$R = 560\,\Omega$

$i = 42.4$ mA

Power

$p = v \cdot i$

Find the power absorbed by each element in the circuit below.



$P_1 = 56$ W

$P_2 = 16$ W

$P_3 = -60$ W

$P_4 = 160$ W

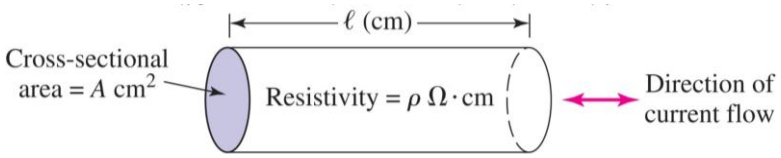
$P_5 = (0.25 \times 12)\,20$

$P_5 = 60$ W

Wire Gauge and Resistivity

The resistance of a wire is determined by the resistivity of the conductor as well as the geometry:

$$R = \rho \, l / A$$



[In most cases, the resistance of wires can be assumed to be 0 ohms.]

Conductance

- We sometimes prefer to work with *the reciprocal of resistance* (1/R), which is called conductance (symbol G, unit siemens (S)).
- A resistor R has conductance G=1/R.
- The *i-v* equation (i.e. Ohm's law) can be written as

$$i = Gv$$

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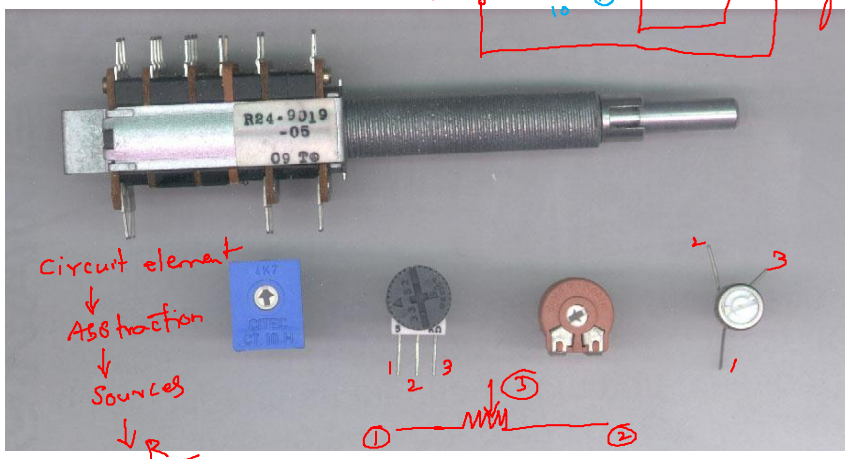
Variable Resistor: Rotary Potentiometers



Circuit element
↓
Abstraction
↓
Sources
↓
R
L
C