# Unit - I
# 1.2 Introduction and Basic Concepts

**Dr.Santhosh.T.K.**

The World's Largest Camera Is Nearly Complete - IEEE Spectrum

- LSST Camera
  - 3.2-billion-pixel
  - weighing around 2,800 kg
  - field of view of 9.6 square degrees


This Idea Wasn't All Wet: The Sensing Water-Saving Showerhead Debuts - IEEE Spectrum

# Syllabus

**UNIT – I** **10 Periods**

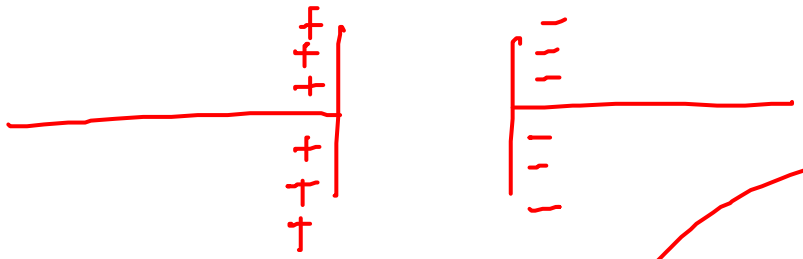
**Introduction and Basic Concepts:** Concept of Potential difference, voltage, current - Fundamental linear passive and active elements to their functional current-voltage relation - Terminology and symbols in order to describe electric networks - Concept of work, power, energy and conversion of energy- Principle of batteries and application.

**Principles of Electrostatics:** Electrostatic field - electric field intensity - electric field strength - absolute permittivity - relative permittivity - capacitor composite – dielectric capacitors - capacitors in series & parallel - energy stored in capacitors - charging and discharging of capacitors.

Ultracapacitors

Supercapacitors

Capacitors



adsorption

Capacity ↑ IF, 5 F

1.3 V

$E = \frac{1}{2} CV^2$

$C = \frac{Q}{V}$

Discharge →

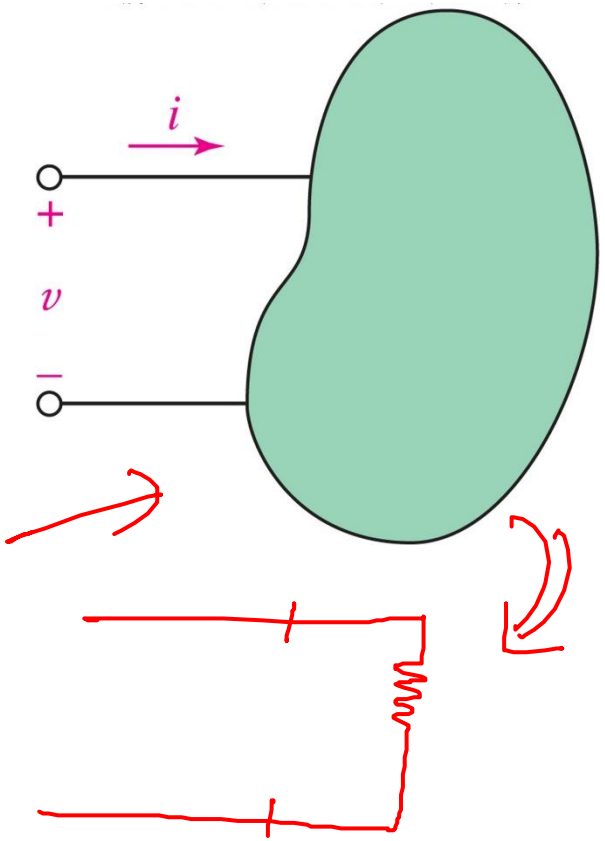
# Circuit Elements

- 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.

- *Lumped Circuit Abstraction*

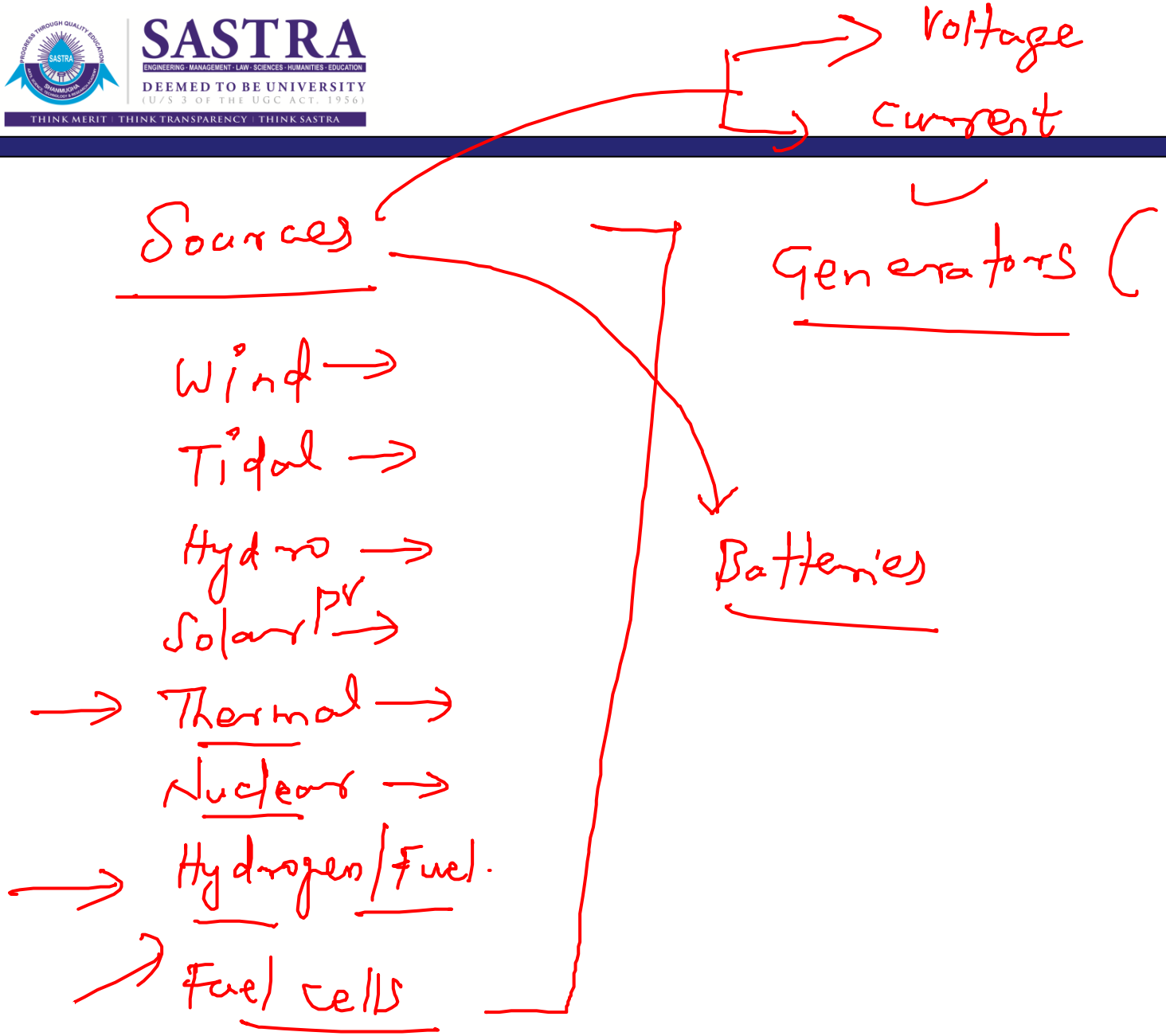
Lumped circuit abstraction



# Linear Elements and Circuits

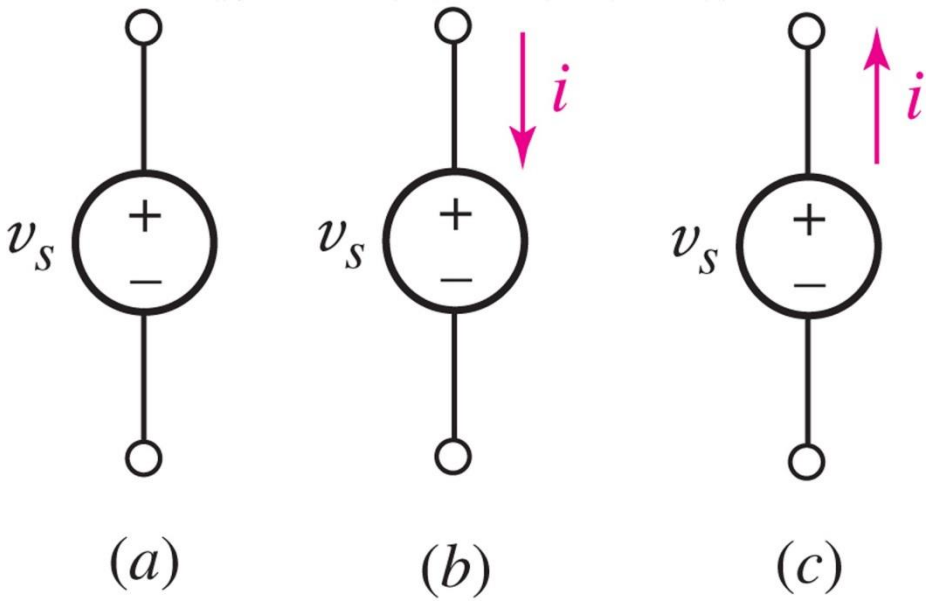
- a linear circuit element has a linear voltage-current relationship:
  - if $i(t)$ produces $v(t)$, then $Ki(t)$ produces $Kv(t)$
  - if $i_1(t)$ produces $v_1(t)$ and $i_2(t)$ produces $v_2(t)$, then $i_1(t) + i_2(t)$ produces $v_1(t) + v_2(t)$,
- resistors, sources are linear elements[1]
- a linear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

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


Voltage
Current
Sources
Generators
Batteries
Wind
Tidal
Hydro
Solar PV
Thermal
Nuclear
Hydrogen/Fuel.
Fuel cells

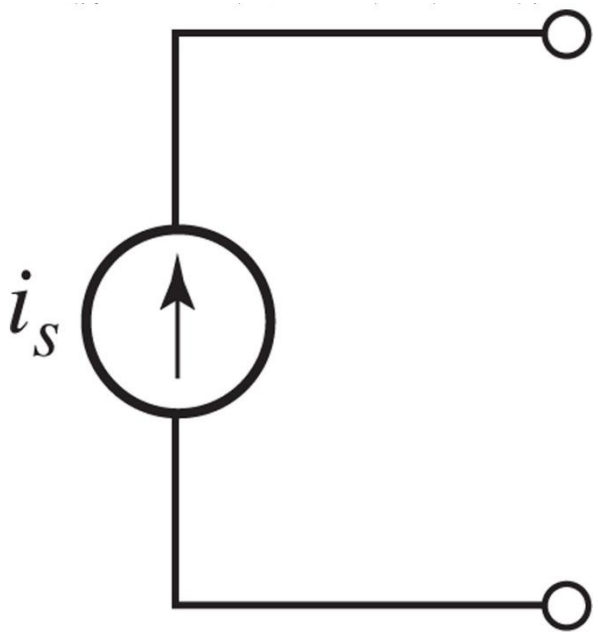
# Voltage Sources

- 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.



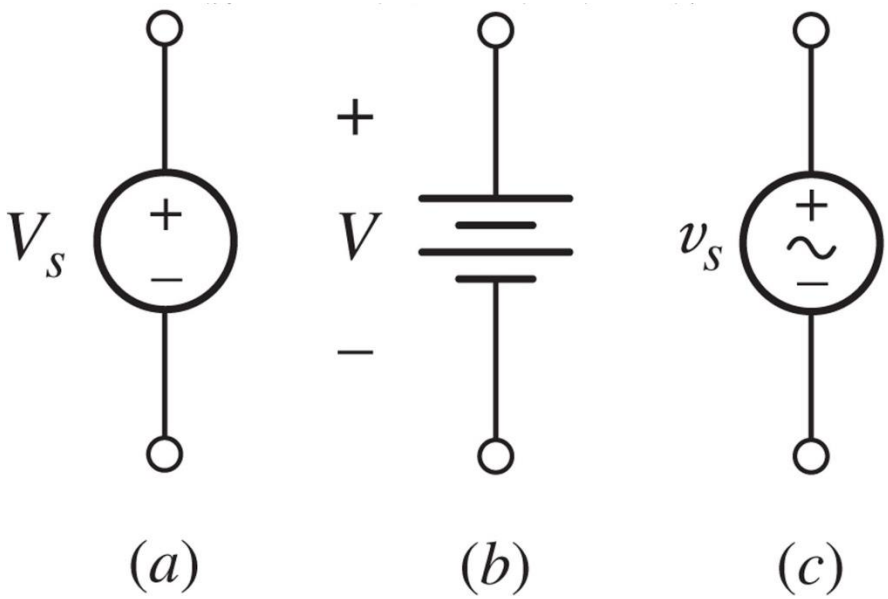
# Current Sources

- 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.



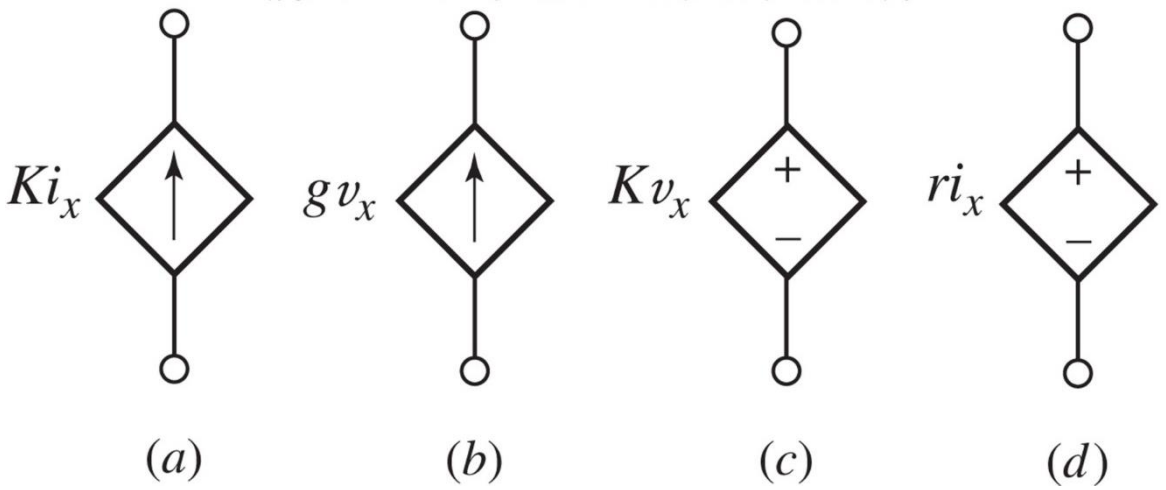
# Battery as Voltage Source

- 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.



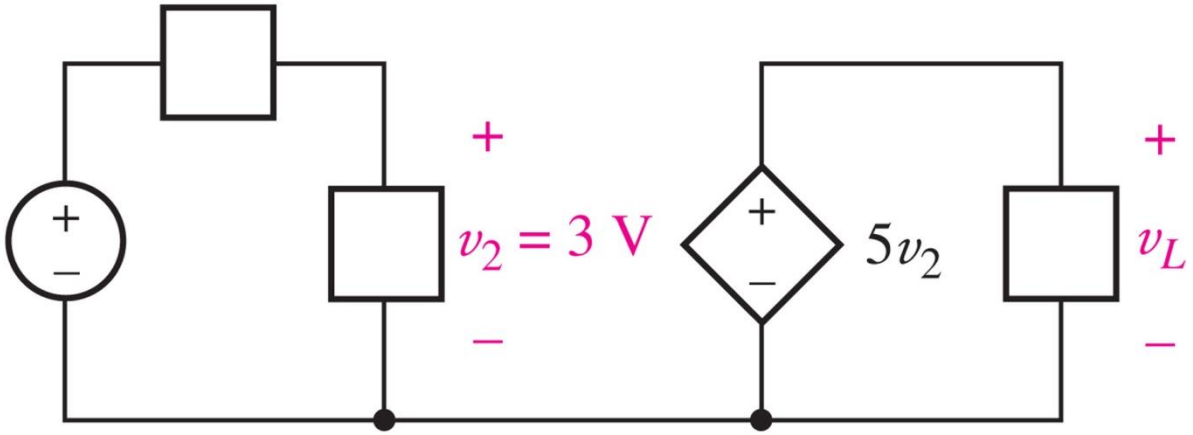
# Dependent Sources

- 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.

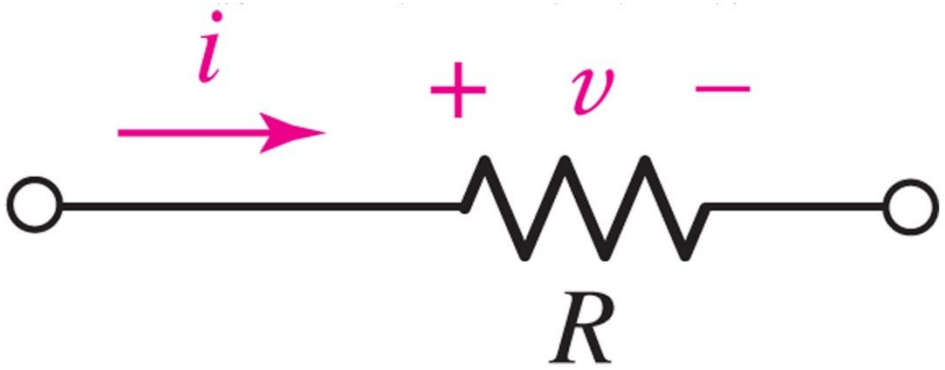


# Ohm's Law: Resistance

- A (linear) resistor is an element for which

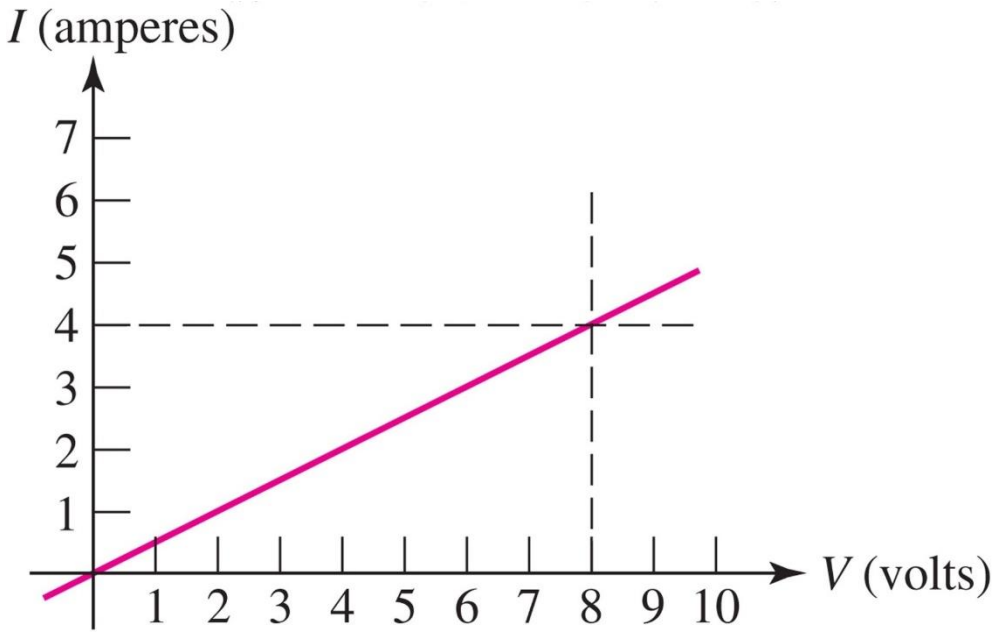
$$v = iR$$

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



# 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 $\Omega^{-1}$.

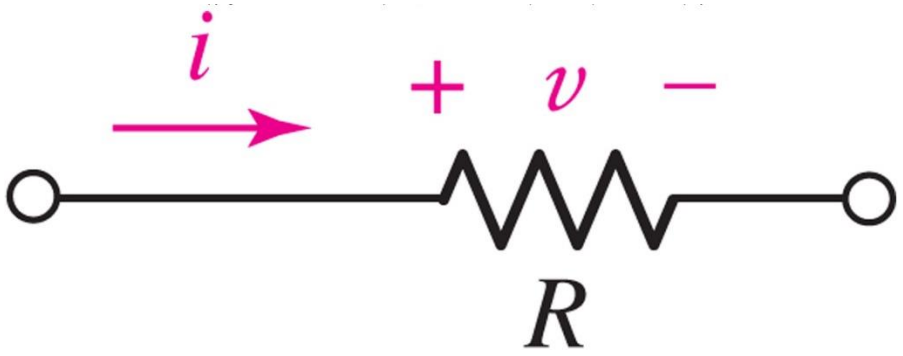
This is the graph for a 2 ohm resistor.

# 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

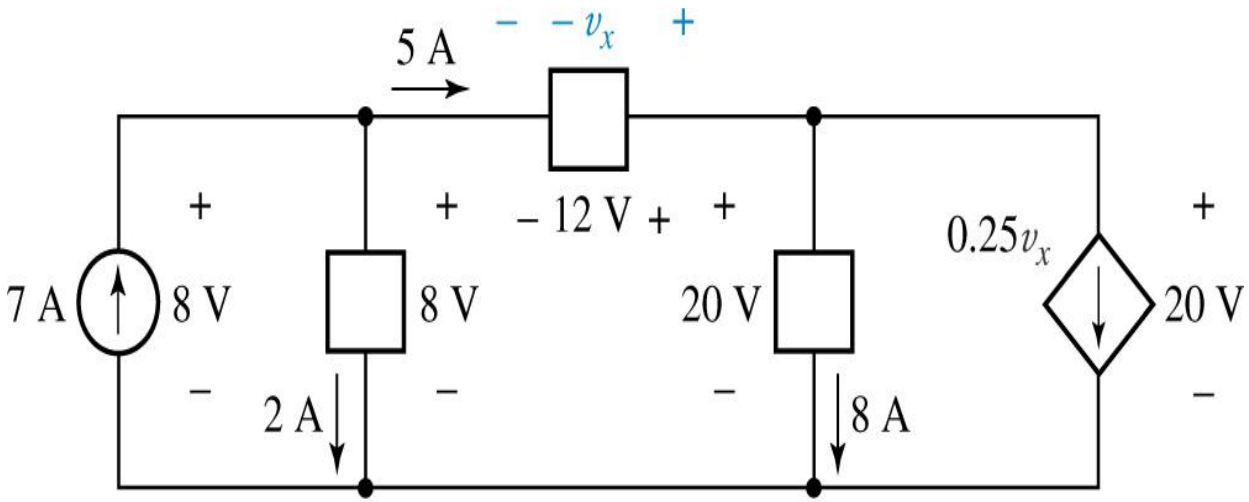
A 560 Ω resistor is connected to a circuit which causes a current of 42.4 mA to flow through it. Calculate the voltage across the resistor and the power it is dissipating.

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

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

# Power

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



# Power

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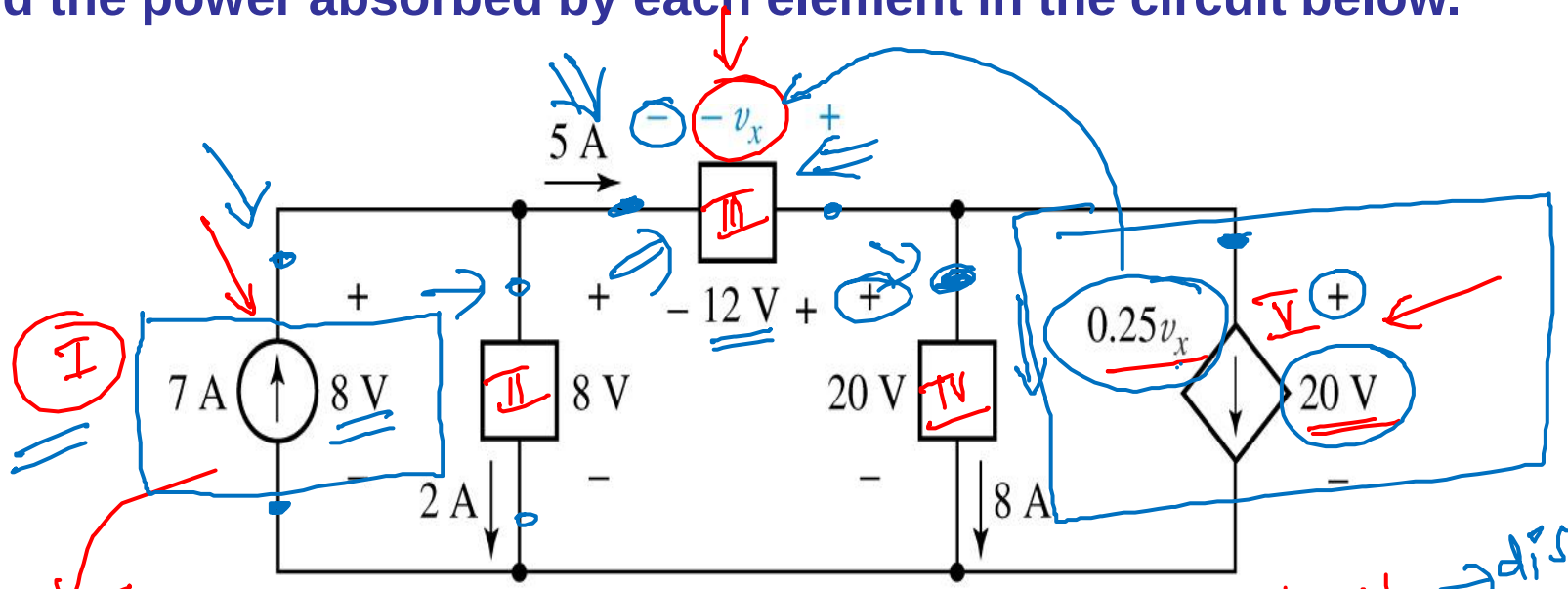



Supplier ← I → 56 W.

dissipate / Supplier: II → 16 W, III → 60 W

IV → 160 W → dissipate

V → dissipate

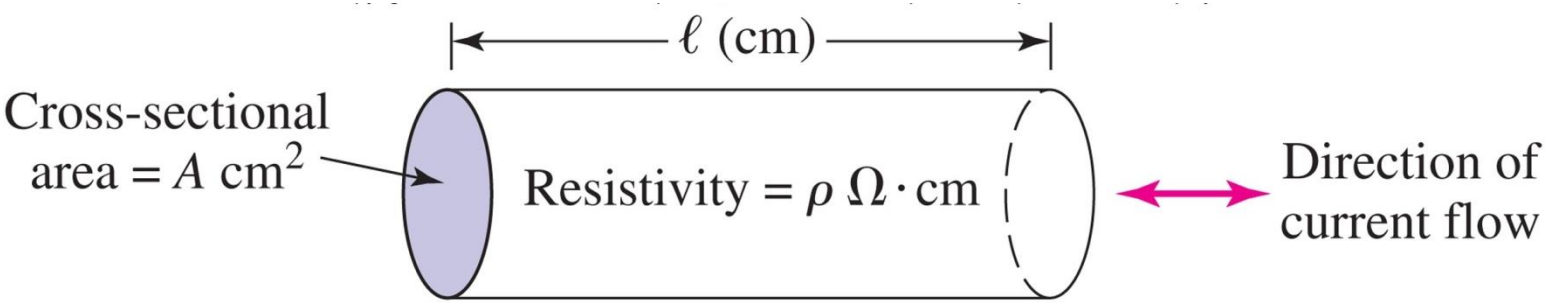
$20 \times 0.25 V_x$

$20 \times 0.25 \times 12$

# 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.

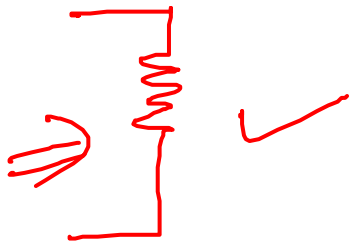
- The *i-v* equation (i.e. Ohm's law) can be written as

$$i=Gv$$

# Summary

Iron box

Lumped circuit abstraction →



Source → Dependent
→ Indep.

Elements → Linear

↓

Resistance →

Exercise