WELCOME TO
CSE 231: Circuits & Electronics

Course Syllabus

<u>Class Time</u>: **Tuesday 10:30 – 12:30**

Thursday 09:30 - 11:30

<u>Instructor</u>: **Dr. Erkan Zergeroğlu**

Office: 202 Computer Engineering Department

E-mail: e.zerger@gtu.edu.tr

<u>Office Hours</u>: **Yet to be determined**

Textbook

- The essentials of electric circuits / M. Fogiel. Fogiel, ISBN. 0-87891-585-0
- Electric circuits fundamentals / Thomas L. Floyd. 1998 ISBN. 013835166X
- Introduction to electric circuits / Richard C. Dorf. 2001 ISBN.0471386898
- Principles of electric circuits / Thomas L. Floyd. 2000 ISBN.0130959979
- Electric circuits / James W. Nilsson, Susan A. Riedel. 2008 ISBN.0130321206
- Fundamentals of electric circuits / Charles K. Alexander, Matthew N.O. Sadiku. 2000 ISBN.0071160426

Homework

- **Homework will be assigned and collected.**
- **Working the homework problems is essential to the learning of the material in this course; <u>in fact, most of your learning will come from doing the homework</u>.**
- **It is expected that your homework will represent your own work, although working in groups is allowed, and even encouraged.**
- **Late homework will not be accepted**

Exams

There will be at least one regular (midterm) closed book exam and a “face to face, on campus ” final exam.

- **Most questions will be circuit analysis problems, including numerical as well as symbolic answers; however, there may be a few conceptual questions as well on each exam.**

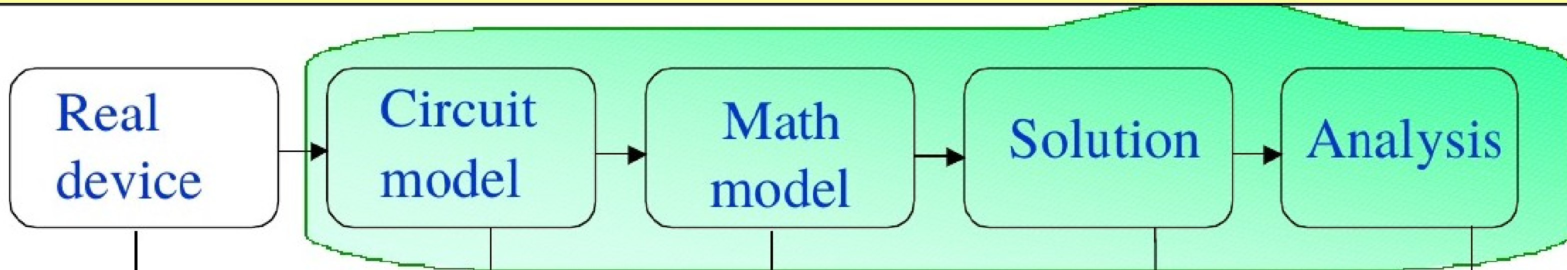
Grading

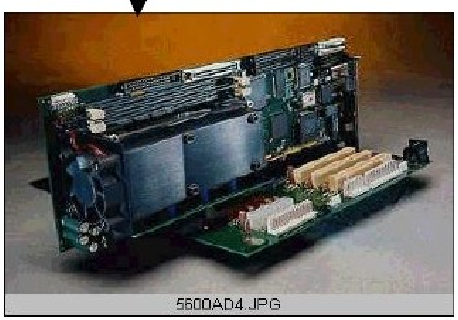
Final Grades will be Determined by Averaging the Homework, Exams, and the Final Exam Based on the Following Scale (This part is subject to change):

Quizzes	**10%**
Homework	**10%**
Midterm Exam	**30 %**
Final Exam	**50%**

Course Grade	**100%**

Overall

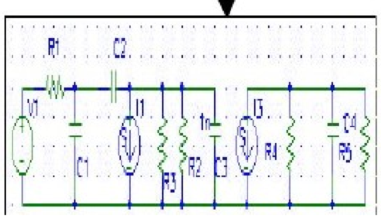




$$\begin{bmatrix} Y_{11} & Y_{12} & Y_{13} & Y_{14} & Y_{15} \\ Y_{21} & Y_{22} & Y_{23} & Y_{24} & Y_{25} \\ Y_{31} & Y_{32} & Y_{33} & Y_{34} & Y_{35} \\ Y_{41} & Y_{42} & Y_{43} & Y_{44} & Y_{45} \\ Y_{51} & Y_{52} & Y_{53} & Y_{54} & Y_{55} \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \\ v_5 \end{bmatrix} = \begin{bmatrix} I_s^1 \\ I_s^2 \\ I_s^3 \\ I_s^4 \\ I_s^5 \end{bmatrix}$$

$v_1 = 1.1V$
$v_2 = 3.2V$
$v_3 = 2.4V$
$v_4 = 5.5V$
$v_5 = 4.5V$

Hurray!!
or
Oops!!



Lecture 1

Circuit Variables

Motivation

- Basis for future courses
- Foundational to Electrical Engineering and Computer Engineering
- Used for actual circuits and circuit models

Circuit Theory

Assumptions:

- Electrical effects are instantaneous
- No magnetic coupling between components

⇒ Lumped-Parameter Model

Circuit Variables

Units and Dimensions

We will use SI Units [International System]

• Length	m
• Mass	kg
• Time	s
• Current	Ampere
• Temperature	K
• Voltage	Volts
• Resistance	Ohms

Some Important Derived Units
Energy

Units are ***Joules*** (*J*)

Energy

Force

Distance

$$E = F\;x \quad \therefore\; J \equiv \frac{kgm^2}{s^2} = N\;m$$

Force over a distance

$\frac{kgm}{s^2}$

m

Unit

$\frac{kgm}{s^2}$

Note: Text uses "*W*" for Energy

Some Important Derived Units (Contd.)
Power

Units are ***Watts*** (W)

$$W = \frac{J}{s} \equiv \frac{Energy}{Time} = \frac{w}{t} \Rightarrow \frac{dw}{dt} = \frac{\text{Change in } w}{\text{Change in } t}$$

$$J \equiv W \cdot s \quad \textbf{OR} \quad kW\text{-}hr$$

Meters read energy
Power companies charge for energy use

Some Important Derived Units (Contd.)
Charge

Units are ***Coulombs*** (C)

$$\left.Coulomb \equiv A \cdot s \equiv Current \times Time\right\} \textbf{Charge}$$

OR

$$Current \equiv \left(\frac{C}{s}\right) \equiv \frac{Charge}{Time}$$

Related to velocity of electrons

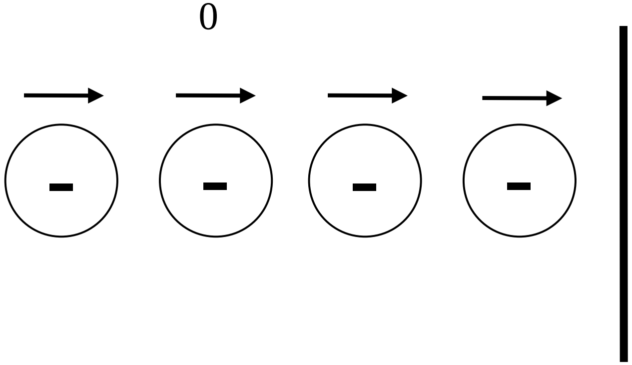
Definition of Current

Current is charge in motion

$$i = \frac{dq}{dt} \quad (\text{Coulombs/second}) \equiv Amperes = \frac{\text{Change in } q}{\text{Change in } t}$$

$$\left. q = \int_0^t i \, dt \quad \therefore \; Q_{total} = \int_0^\infty i \, dt \right\}$$

Integrate above expression



Current in Amperes or Amps

$\equiv$ # Coulombs which cross a given point in 1 second

Electrons moving or flowing through a wire is a current
These electrons are “moved” by a voltage

Some Important Derived Units (Contd.)
Voltage

Definition of Voltage

$$V \equiv \frac{w}{q} \equiv \frac{Joules}{Coulomb}$$

$$\equiv Voltage$$

V_{a-b} $\equiv$ Work required to move charge from point "a" to "b" (Book uses energy)

$$V = \frac{dw}{dq} = \frac{\text{Change in } w}{\text{Change in } q}$$

Some Important Derived Units (Contd.)
Resistance

Units are ***Ohms*** (Ω)

$$\Omega = \frac{V}{A}$$ Ohm's Law

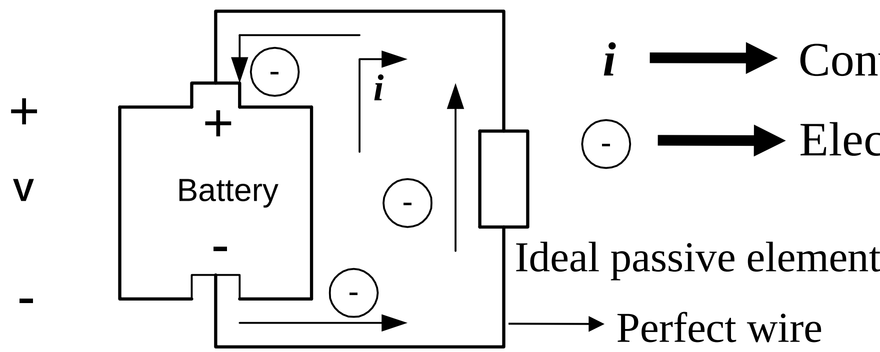
$\Rightarrow$ Implication: $V = IR$

Voltage = Current x Resistance $\}$ **Ohm's Law**

Voltage and Current

Separation of Charge ⇒ Force between charge ⇒ **Voltage**

Voltage moves electrons ⇒ **Current**



i → Conventional Current

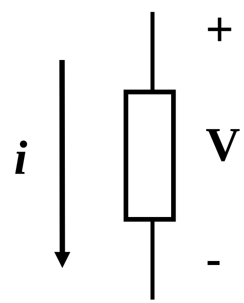
(-) → Electron

Conventional current, "***i*** ", flows in the Opposite direction to the electrons (Thanks to Ben Franklin)

+ Terminal attracts electrons

- Terminal repels electrons

Ideal Passive Element (seen above) ⇒

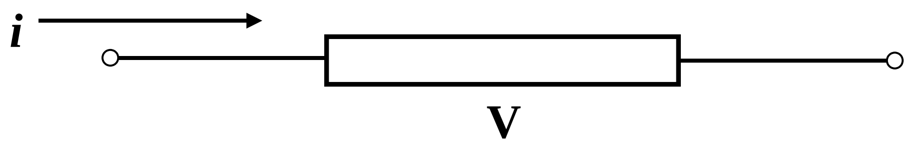


i flows "**through**" the element

V is "**across**" the element

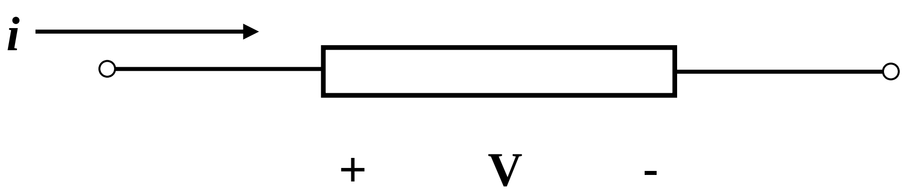
(drop or rise)

Passive Sign Convention



What are the polarities?

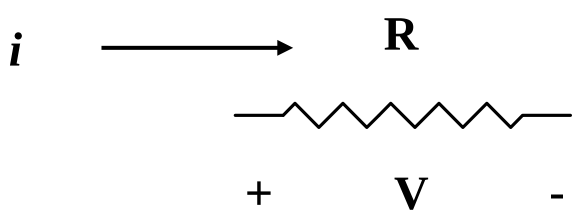
- The current ***i*** flows to the right
- What is the polarity of **V**?
- General element, so we don't know really



Passive sign convention

Variables are "Positive" in the equations

Passive Sign Components



Can't add energy or power → **Passive**

Loses energy Current goes through a drop → **Passive**

<u>This is not reality for "**Active**" Components</u>

- Does add energy or supply power
- Current goes through a rise ⇨ Gain in energy

A battery is an active component

Convention is based on "**Passive**" components.

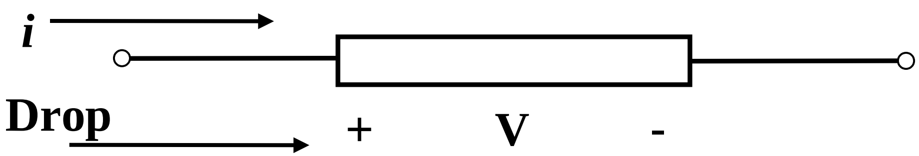
Implications

Variables are treated as positive when the polarities are consistent with the "**Passive Sign Convention**"

<u>Example/Illustration</u>

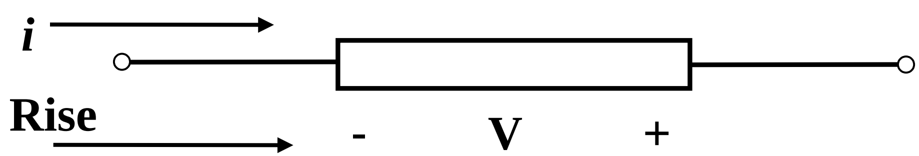
Taken as Fact: Power = Voltage x Current

Standard Polarity



$$p = +Vi$$

Reverse Polarity



$$p \neq Vi$$

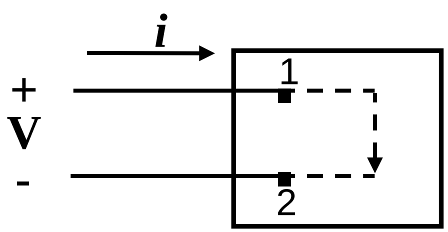
$$p = -Vi$$

POSITIVE CURRENT WILL NOT FLOW IN THE REVERSE POLARITY FOR A PASSIVE COMPONENT

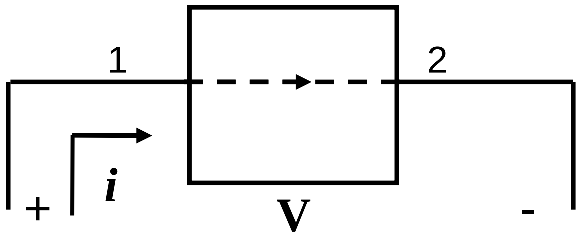
Ideal Circuit Elements

- 2 Terminal devices
- Described by **V** and/or ***i***
- Basic Element

Two ways to represent this schematically



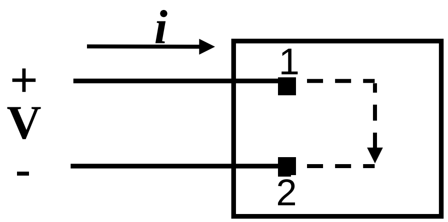
Nilsson and Reidel



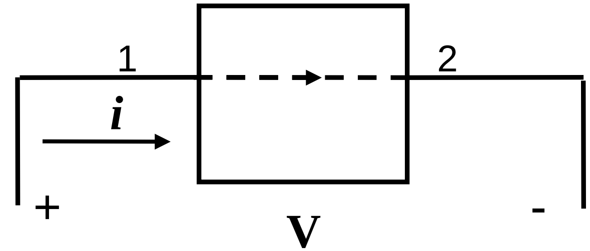
Dr. Harrell's

- Current "***i***" flows through the element.
- Voltage "**V**" is across the element.

Ideal Circuit Elements (Contd.)



Nilsson and Reidel



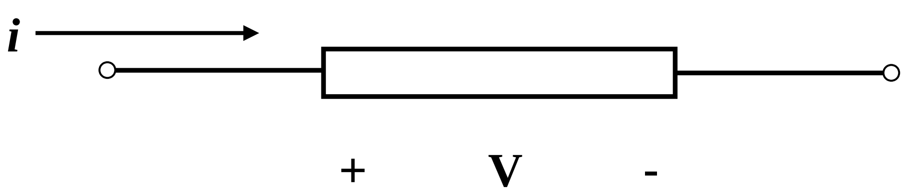
Dr. Harrell's

<u>For positive **V** and ***i***</u>

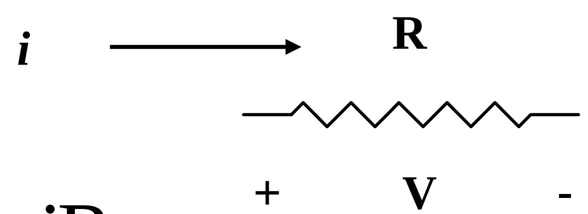
- ⇨ Voltage drop from 1 to 2 {+ to -}
- ⇨ Voltage rise from 2 to 1

- ***i*** flows from 1 to 2: direction of + charge flow.
- "-" charge {electrons} flows opposite to ***i***.

<u>Passive Sign Convention</u>



$$V = iR$$



Power and Energy

Power $\equiv$ Energy/Time

$$p = \frac{dw}{dt} \qquad \left\{ Watt = \frac{J}{s} \right\} = \frac{\text{Change in Energy}}{\text{Change in Time}}$$

$$p = \frac{dw}{dt} \equiv \left(\frac{dw}{dq} \right) \left(\frac{dq}{dt} \right) \quad \Big\} \text{ **Use the fact that** } \frac{dq}{dq} = 1$$

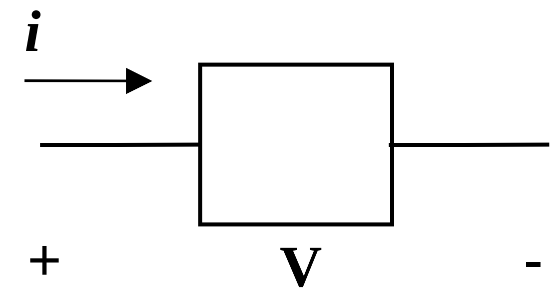
$$V = \frac{dw}{dq} \qquad i = \frac{dq}{dt}$$

$$\therefore \quad \boxed{p = Vi}$$

Derived Power Formula

Power Delivery or Extraction

ELEMENT



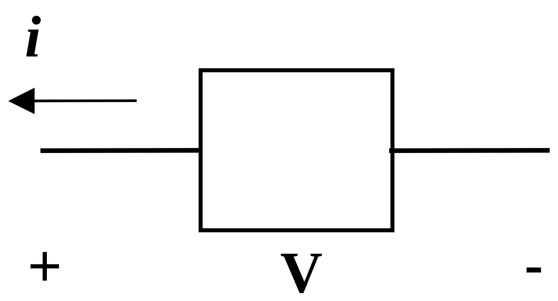
$p = Vi$

$\oplus \longrightarrow$ a drop $\Rightarrow$ lose energy

Power **delivered to OR absorbed by** element (Resistor)

$p > 0$	**Power delivered to element**

SUPPLY



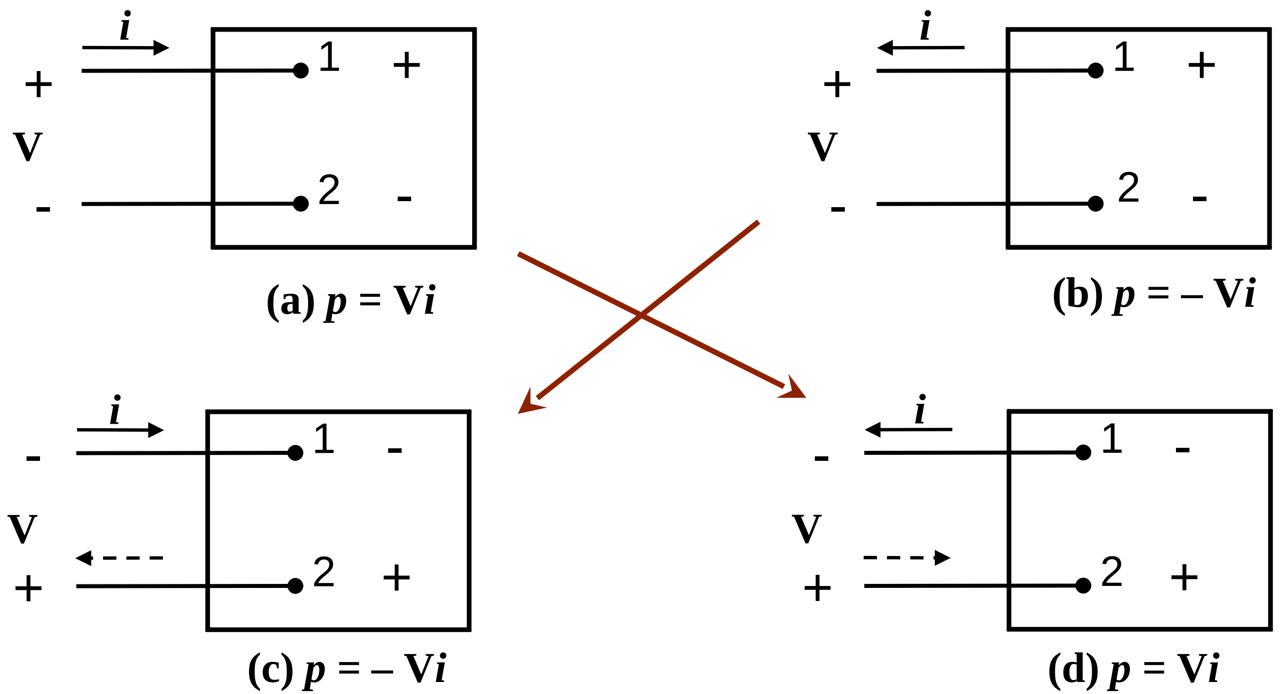
$p = -Vi$

$\oplus \longrightarrow$ a rise $\Rightarrow$ gain energy

Power **extracted from OR delivered by** element (Power Supply)

$p < 0$	**Power extracted from element**

Find the Power Equation for the element in the box



(a) $p = Vi$

(b) $p = -Vi$

(c) $p = -Vi$

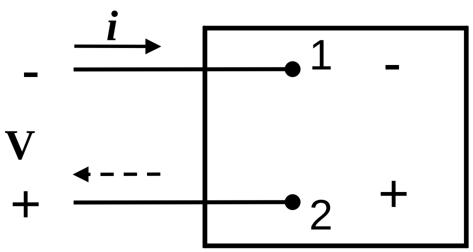
(d) $p = Vi$

$p > 0$ **Power Absorbed**

$p < 0$ **Power Delivered**

$$\sum p_{Absorbed} + \sum p_{Delivered} = 0$$ **Conservation of Energy**

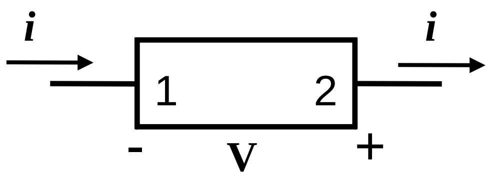
Example



<u>From the previous figure part (c)</u>

Let **V** $= 10\ (V)$
$\qquad \boldsymbol{i} = -2\ (A)$

1. Write equation:



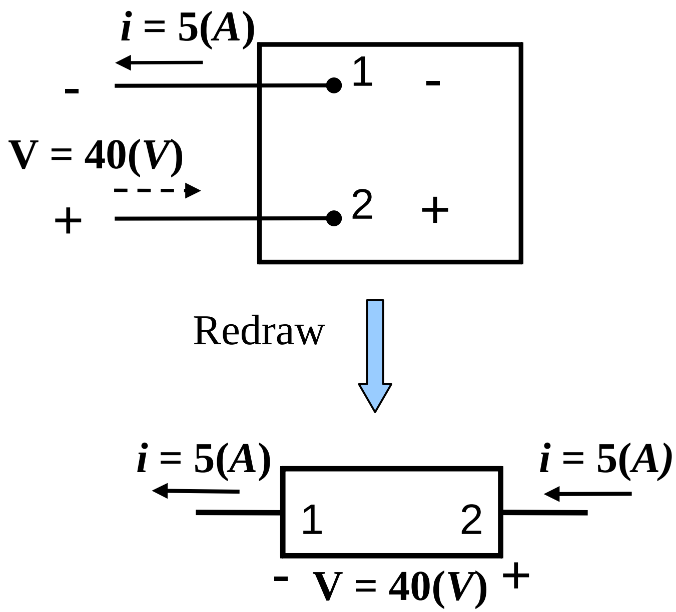
$$\boldsymbol{p} = -\mathbf{V}\boldsymbol{i}$$

2. Plug in values:

$$p = -(10)(-2) = \mathbf{+20}\ \boldsymbol{(W)}$$

$\boldsymbol{p} > \mathbf{0}$ Power **absorbed** by element.

Example Problem



Similar to Fig. (d)

Redraw as shown.

(a) Calculations:

$$p = \mathrm{V}i$$
$$= (40)(5)$$
$$= 200$$

p > 0
Absorbed *by* box
Delivered *to* box

(b) Electrons leave terminal 2

(c) Electrons *lose energy*

Positive charges *lose energy*

Through Voltage drop

New Example:

V = – 40 (V)

i = 5 (A)

Calculated or specified values

then

p < 0

p = Vi = **– 200 (*W*)**

Power Extracted ***from*** box