Dr. Shimaa Ismail

Lecture 1

Electronics

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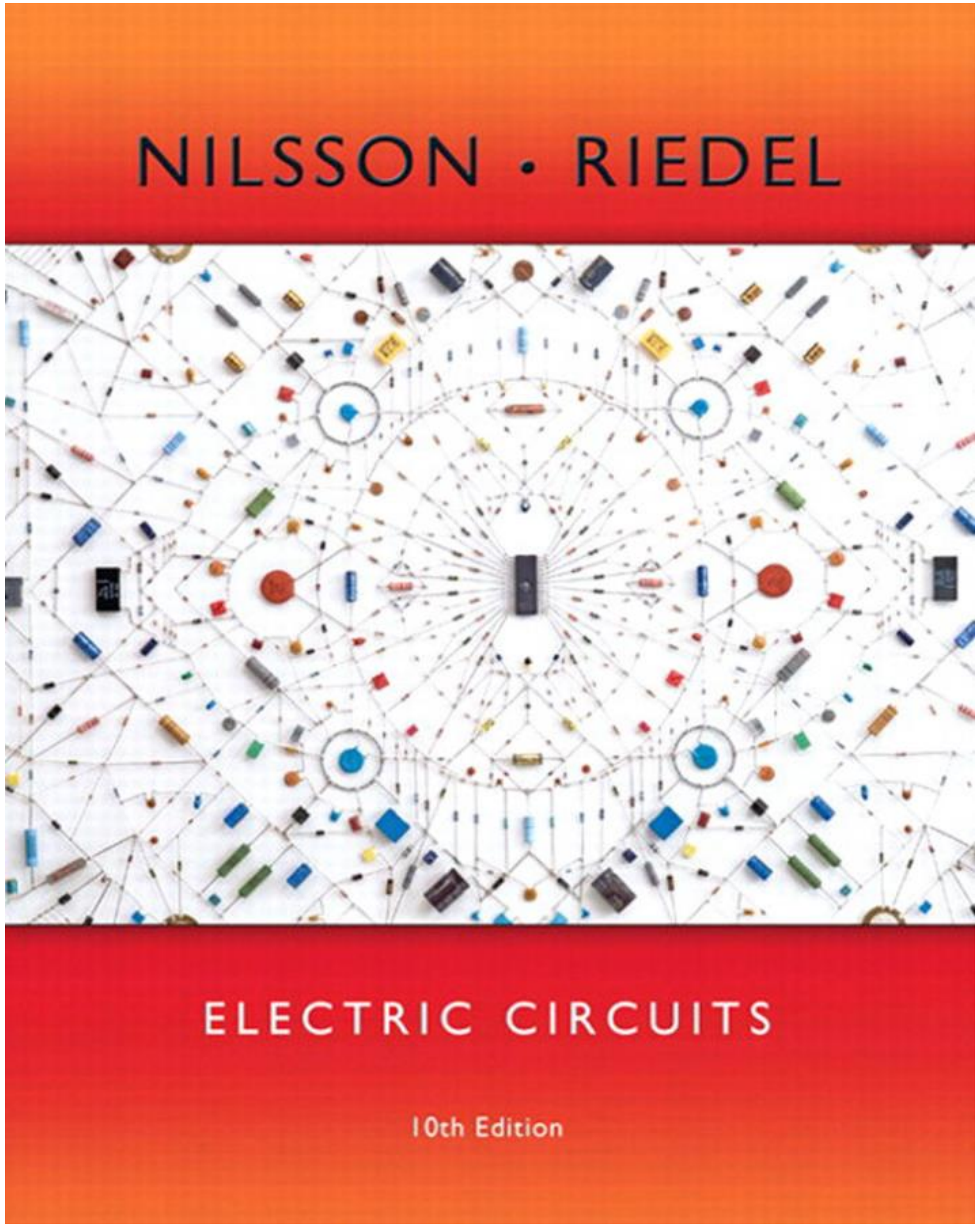


Course Information

- **Course Code: BS131**
- **Course Materials:**
  - Lecture Notes
  - Assignments
  - Lab Manual
  - Lab Assignments

- **Textbook:**
- Nilsson J.W., Reidel S. Electric Circuits. 10th Edition, Prentice Hall

Course Policy

- Students are expected to participate and attend the class in time.
- Students are responsible to submit assignments in time.
- Exams will be a combination of lectures in class and homework assignments.
- There are two Midterms that will be carried out in this semester.
- A homework paper will not be accepted after graded papers have been returned, after a solution has been distributed, or after the final examination.

Absence Policy and Examination

- Students absent that exceeds (25% lectures) are being considered dropped from the course.
  - After 2 lectures absent a warning is issued for the student.
  - After 3 lectures absent student will be dropped from the class.
- There will be no alternative exams except under emergencies.
- If a student cannot attend the exam, then student must make arrangement with the instructor prior to the planned absence.
- The emergency alternative exam will be either written or oral.

Grading

- An absolute grading scheme will be used to assess your final grade:

	Grade
Mid-Term 1	15%
Mid-Term 2	15%
Attendance & Assignments	15%
Labs	15%
Final Exam	40%

- You should get 30% of the final degree to pass the course

(about 12 marks)

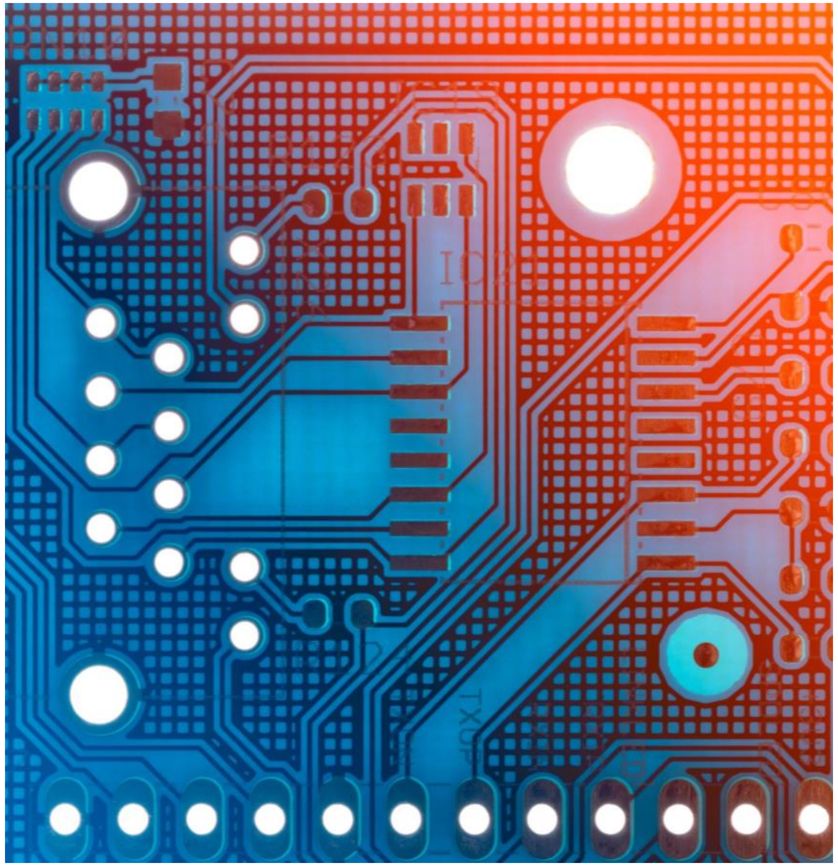
Chapter 1: Circuit Variables

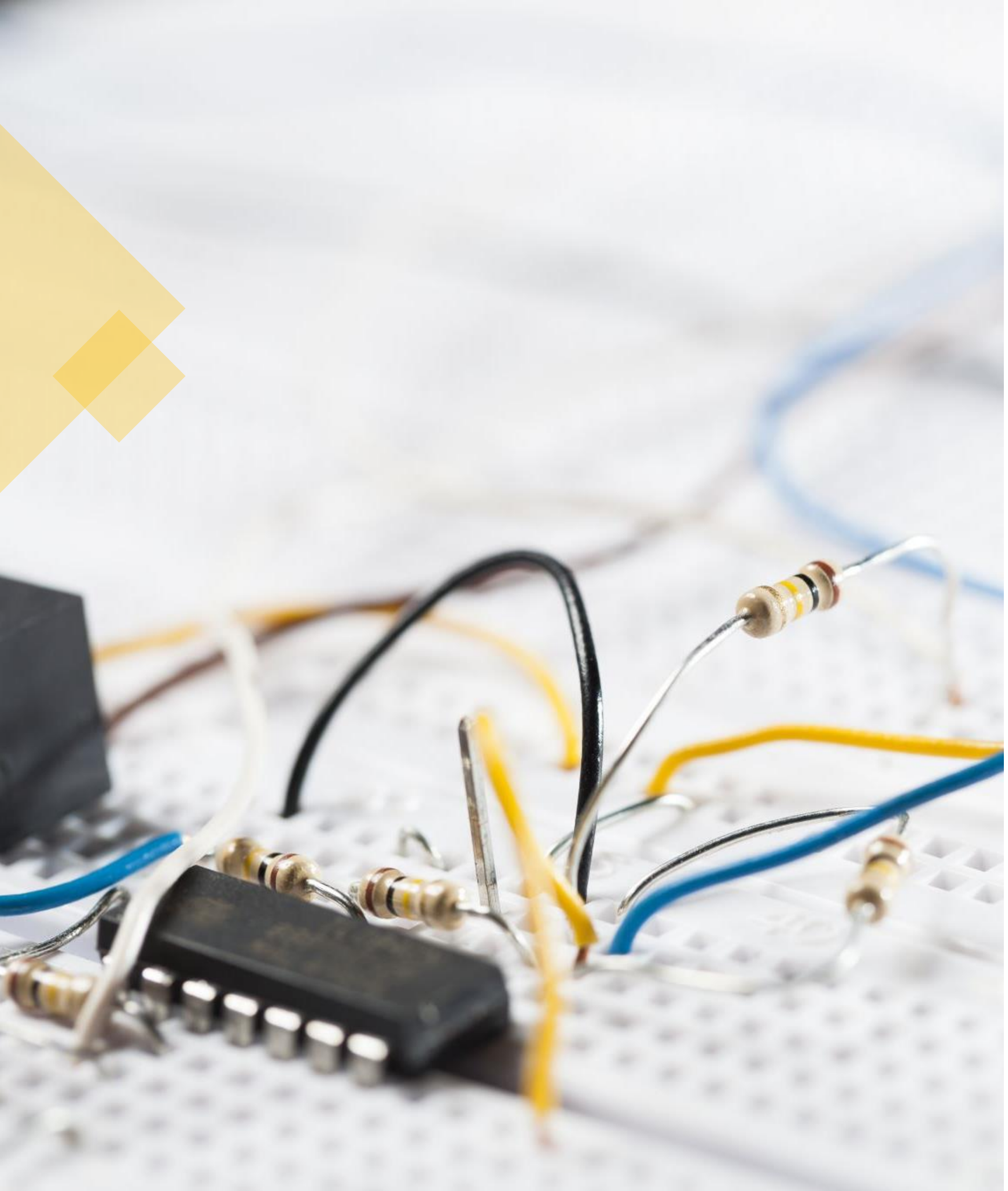
CHAPTER CONTENTS

- Electrical Engineering: An Overview
- The International System of Units
- Circuit Analysis: An Overview
- Voltage and Current
- The Ideal Basic Circuit Element
- Power and Energy

CHAPTER OBJECTIVES

- Understand and be able to use SI units and the standard prefixes for powers of 10.
- Know and be able to use the definitions of *voltage* and *current*.
- Know and be able to use the definitions of *power* and *energy*.
- Be able to use the passive sign convention to calculate the power for an ideal basic circuit element given its voltage and current.





Electronics Definition

- **<u>What do we mean by Electronics?</u>**

- **Electronics** covers the physics, engineering, technology and applications that deal with the emission, flow and control of electrons in vacuum and matter.

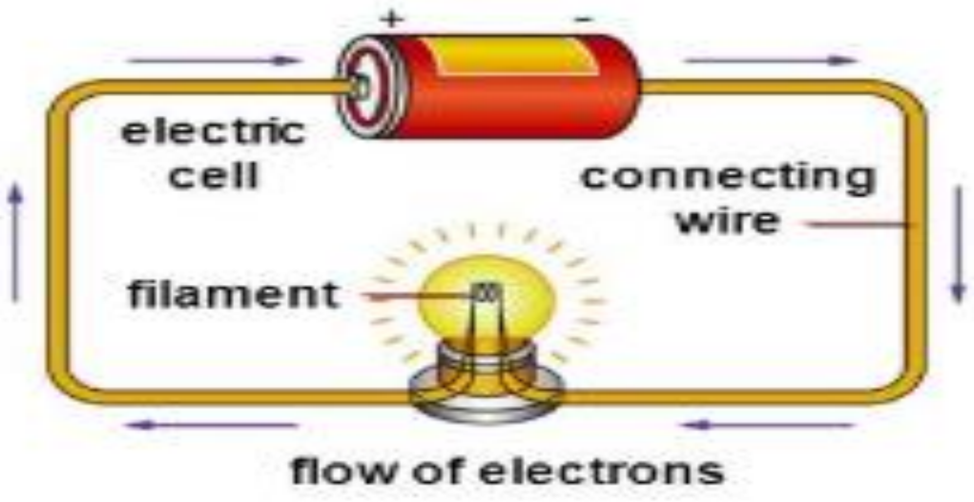
Branches of Electronics

- Digital electronics
- Analogue electronics
- Microelectronics
- Circuit design
- Integrated circuits
- Power electronics
- Optoelectronics
- Semiconductor devices
- Embedded systems
- Audio electronics
- Telecommunications
- …

Circuit Theory

- Mathematical model that approximates the behavior of an actual electrical system.
- Commonly used to refer to an actual electrical system as well as to the model that represents it.

An electric circuit is an interconnection of electric components such that electric charge is made to flow along a closed path (a circuit), usually to perform some useful task.



Functions:
To transfer energy from one point to another.

Basic Concepts:

- ✓ Charge.
- ✓ Current.
- ✓ Voltage.
- ✓ Power.
- ✓ Circuit elements.
- ✓ Energy.

SI and Prefix

Engineers compare theoretical results to experimental results and compare competing engineering designs using quantitative measures. Engineers communicate using standard language of measurement: International System of Units (SI) adopted in 1960

Basic Units

TABLE 1.1 The International System of Units (SI)

Quantity	Basic Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	degree kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

TABLE 1.3 Standardized Prefixes to Signify Powers of 10

Prefix	Symbol	Power
atto	a	10^{-18}
femto	f	10^{-15}
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}
deka	da	10
hecto	h	10^{2}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

SI and Prefix

Engineers compare theoretical results to experimental results and compare competing engineering designs using quantitative measures. Engineers communicate using standard language of measurement: International System of Units (SI) adopted in 1960

These are derived from basic units

Derived Units

TABLE 1.2 Derived Units in SI

Quantity	Unit Name (Symbol)	Formula
Frequency	hertz (Hz)	s^{-1}
Force	newton (N)	$kg \cdot m/s^2$
Energy or work	joule (J)	$N \cdot m$
Power	watt (W)	J/s
Electric charge	coulomb (C)	$A \cdot s$
Electric potential	volt (V)	J/C
Electric resistance	ohm (Ω)	V/A
Electric conductance	siemens (S)	A/V
Electric capacitance	farad (F)	C/V
Magnetic flux	weber (Wb)	$V \cdot s$
Inductance	henry (H)	Wb/A

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hecto	h	10^{2}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}
tera	T	10^{12}

Charge, Current and Voltage

Charge – The concept of electric charge is the basis for describing all electrical phenomena.

Let's review some important characteristics of electric charge:

- The charge is bipolar, meaning that electrical effects are described in terms of positive and negative charges,
- The electric charge exists in discrete quantities, which are integral multiples of the electronic charge,
- Electrical effects are attributed to both the separation of charge and charges in motion.

In circuit theory, the separation of charge creates an electric force (voltage), and the motion of charge creates an electric fluid (current).

Charge, Current and Voltage

Charge – the most basic quantity of electric circuit – measured in Coulomb (C)

Elements of an atom : electrons, protons and neutron

negative charge   positive charge   neutral

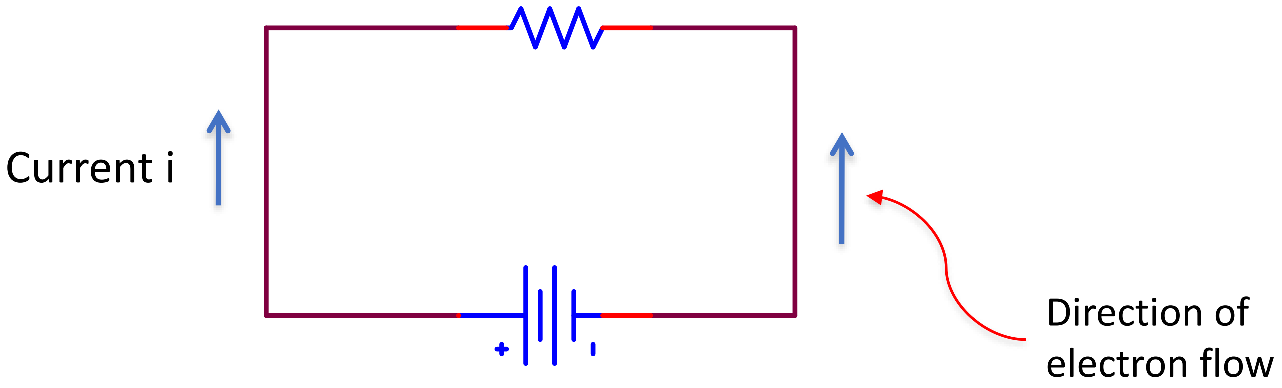
1 electron carries 1.602×10^{-19} C of (negative) charge

i.e. - 1 C consist of $1/(1.602 \times 10^{-19})$ of electrons

$= 6.24 \times 10^{18}$ electrons

Charge, Current and Voltage

The electrical effects caused by charges in motion depend on the rate of charge flow. The rate of charge flow is known as the **Electric Current**, measured in amperes (A)



Direction of current flow = movement of positive charge

Current : time rate of change of (positive) charge

Mathematically, $$i = \frac{dq}{dt}$$

i = the current in amperes,

q = the charge in coulombs,

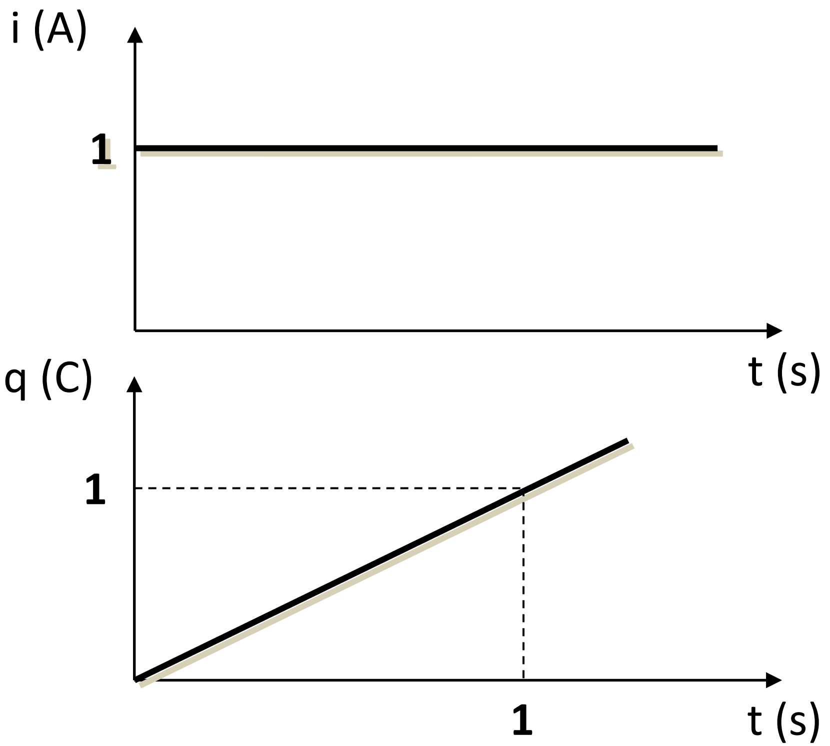
t = the time in seconds.

Charge, Current and Voltage

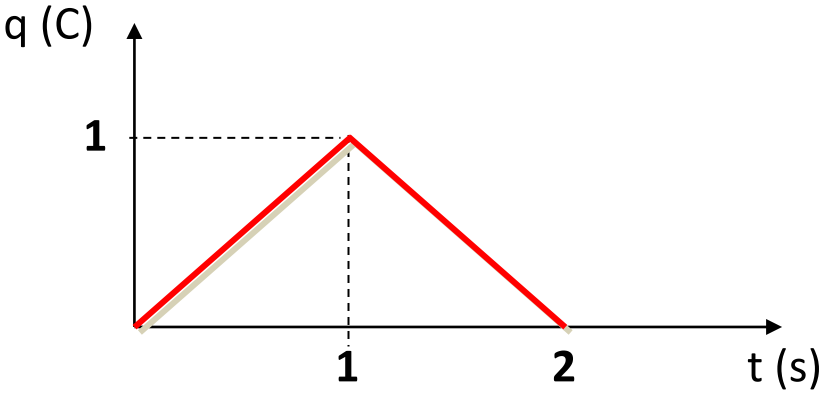
$$i = \frac{dq}{dt} \quad \Rightarrow \quad q = \int_{t_o}^{t} i \; dt$$

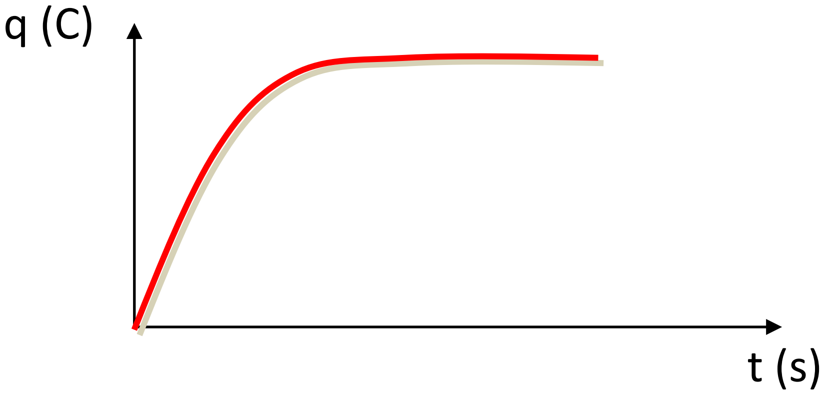
- Charge transferred between t_o and t

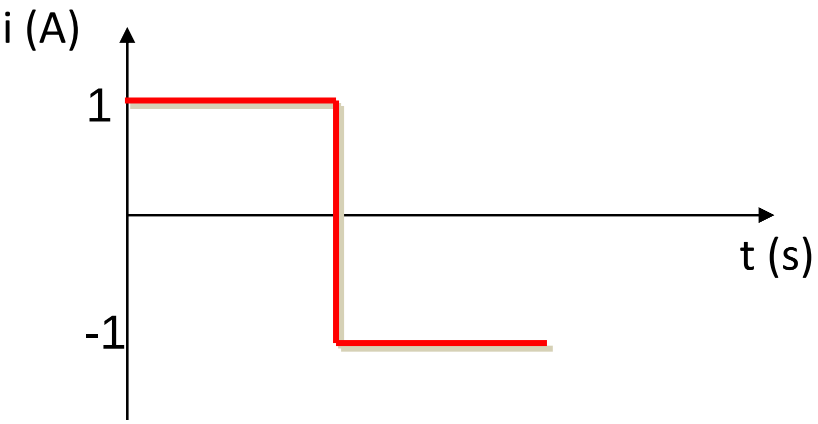
e.g. 1 A = 1 coulomb of charge flows in 1 second

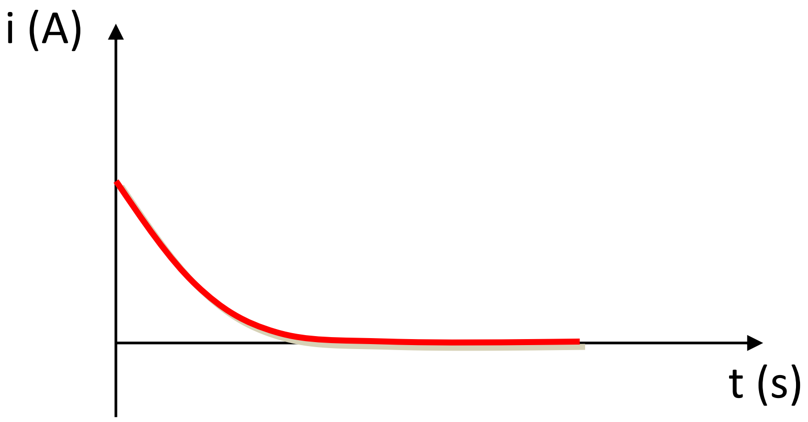


Charge, Current and Voltage



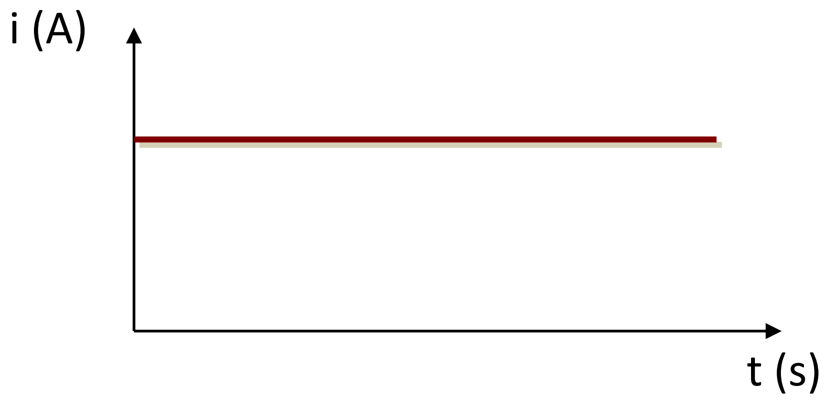






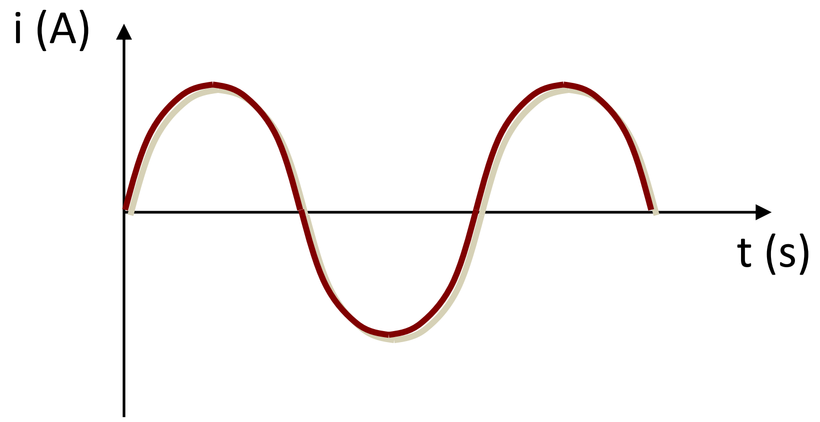
Charge, Current and Voltage

Two common types of current flow



Direct current - DC

- constant with time



Alternating current - AC

- varies sinusoidally with time

we will discuss more on this later in the course

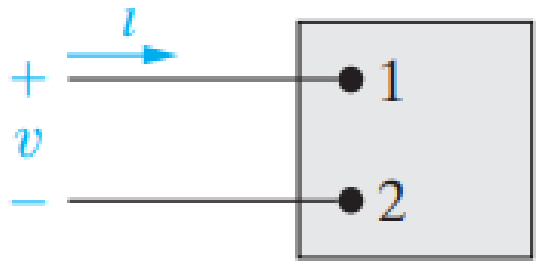


Figure 1.5 ▲ An ideal basic circuit element.

Example 1.2 **Relating Current and Charge**

No charge exists at the upper terminal of the element in Fig. 1.5 for $t < 0$. At $t = 0$, a 5 A current begins to flow into the upper terminal.

a) Derive the expression for the charge accumulating at the upper terminal of the element for $t > 0$.

b) If the current is stopped after 10 seconds, how much charge has accumulated at the upper terminal?

Solution

a) From the definition of current given in Eq. 1.2, the expression for charge accumulation due to current flow is

$$q(t) = \int_0^t i(x)dx.$$

Therefore,

$$q(t) = \int_0^t 5dx = 5x\Big|_0^t = 5t - 5(0) = 5t \text{ C} \quad \text{for } t > 0.$$

b) The total charge that accumulates at the upper terminal in 10 seconds due to a 5 A current is $q(10) = 5(10) = 50$ C.

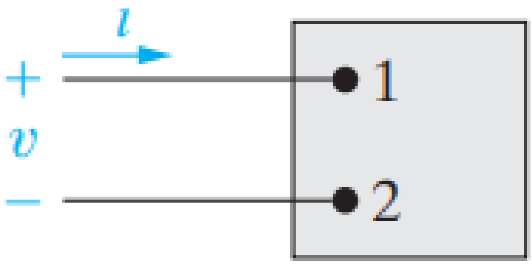


Figure 1.5 ▲ An ideal basic circuit element.

1.3 The current at the terminals of the element in Fig. 1.5 is

$$i = 0, \qquad t < 0;$$

$$i = 20e^{-5000t}\ \text{A}, \quad t \geq 0.$$

Calculate the total charge (in microcoulombs) entering the element at its upper terminal.

AP 1.3 Remember from Eq. (1.2), current is the time rate of change of charge, or $i = \frac{dq}{dt}$ In this problem, we are given the current and asked to find the total charge. To do this, we must integrate Eq. (1.2) to find an expression for charge in terms of current:

$$q(t) = \int_0^t i(x)\,dx$$

We are given the expression for current, i, which can be substituted into the above expression. To find the total charge, we let $t \to \infty$ in the integral. Thus we have

$$q_{\text{total}} = \int_0^\infty 20e^{-5000x}\,dx = \frac{20}{-5000}e^{-5000x}\Big|_0^\infty = \frac{20}{-5000}(e^{-\infty} - e^0)$$

$$= \frac{20}{-5000}(0 - 1) = \frac{20}{5000} = 0.004 \text{ C} = 4000\,\mu\text{C}$$

Charge, Current and Voltage

Whenever positive and negative charges are separated, energy is expended.

Voltage (potential difference) between two points, being equal to the electrical energy gained by a unit positive electric charge moving from one point to the other. measured in **volts (V)**

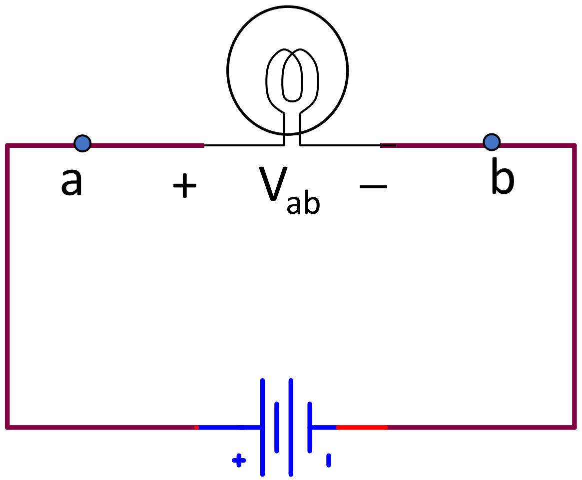
Mathematically, $$v = \frac{dw}{dq},$$

1 V = 1 J/C

v = the voltage in volts,
w = the energy in joules,
q = the charge in coulombs.

Charge, Current and Voltage

Voltage (potential difference) between two points, being equal to the electrical energy gained by a unit positive electric charge moving from one point to the other.

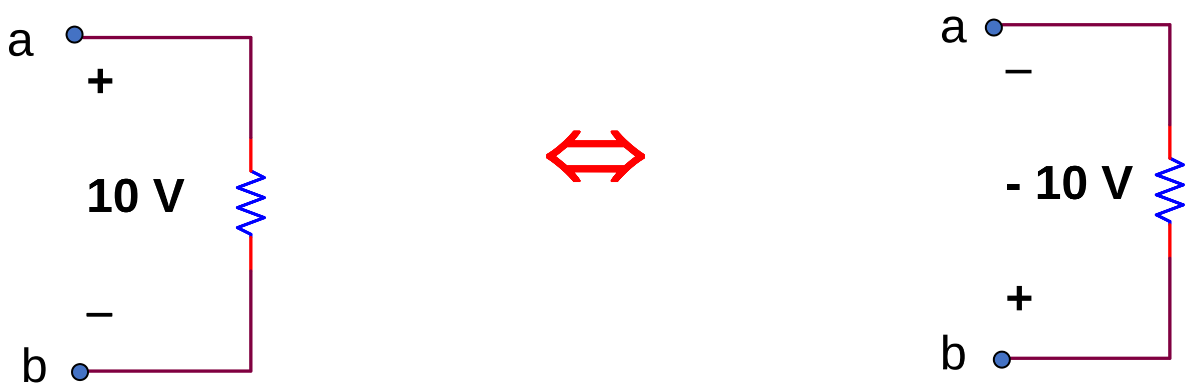


V_{ab} : Electrical energy gained by a unit positive charge when it moves from b to a

"Point a is at potential of V_{ab} higher than point b"

"Potential at point a with respect to point b is V_{ab}"

Charge, Current and Voltage



"Point a is at potential of 10 V higher than point b"

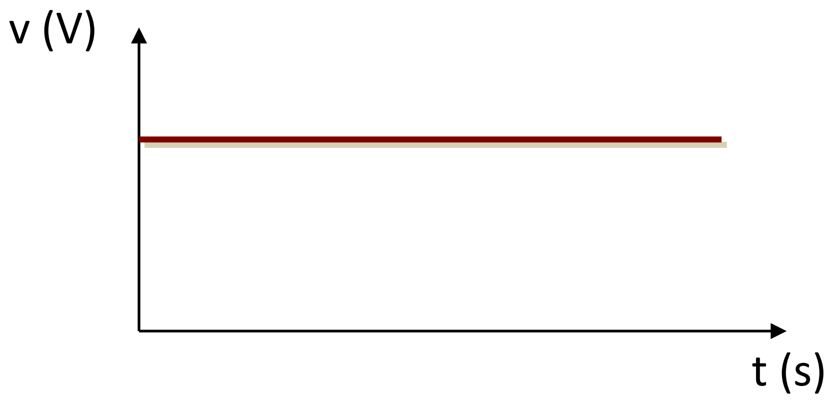
"Point b is at potential of 10 V lower than point a"

"Point a is at potential of -10 V lower than point b"

"Point b is at potential of -10 V higher than point a"

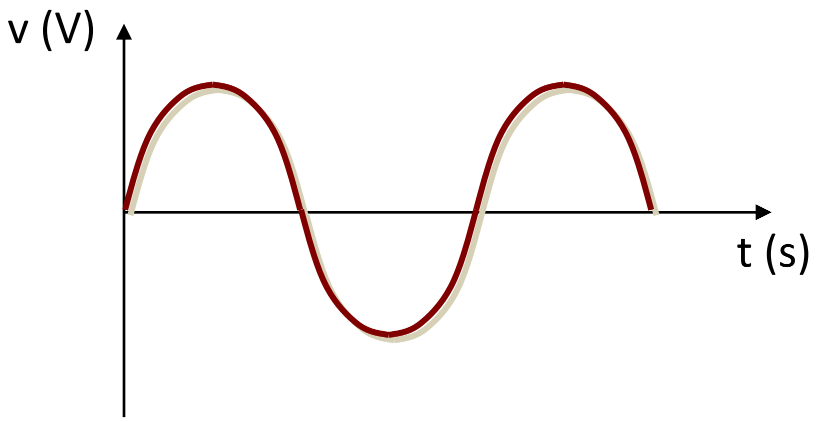
Charge, Current and Voltage

Two common types of voltage



DC Voltage

- constant with time



AC Voltage

- varies sinusoidally with time

Power an Energy

Power is "the time rate of expending or absorbing Energy."
Mathematically, energy per unit time is expressed in the form of a derivative, or

$$p = \frac{dw}{dt},$$

p = the power in watts,

w = the energy in joules,

i = the time in seconds.

power is measured in watts (W)

$$p = \frac{dw}{dt} = \left(\frac{dw}{dq}\right)\left(\frac{dq}{dt}\right),$$

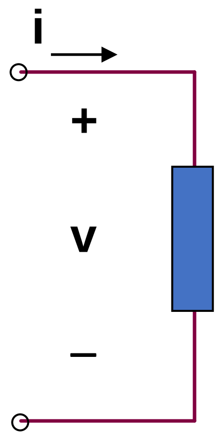
$$p = vi$$

Power an Energy

$$p = vi$$

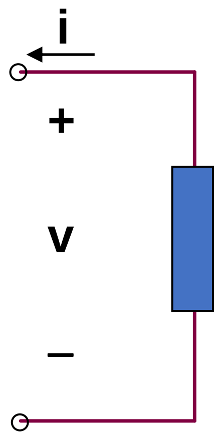
- Power of an element is the product of voltage across it and the current through it

- Use the Passive Sign Convention when calculating power:



p= vi

Absorbing power



p= -vi

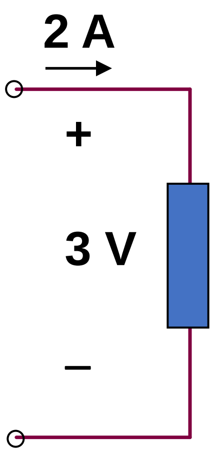
Supplying power

Power an Energy

- Using passive sign convention, power can either be positive or negative

ABSORBED SUPPLIED

Examples



Using passive sign convention,

Power absorbed , $p = 2 \times 3 = 6$ W

Power an Energy

- Using passive sign convention, power can either be positive or negative

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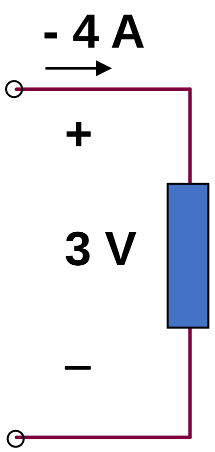
Examples



Using passive sign convention,

$p = -4 \times 3 = -12\ W$

Power supplied

Power an Energy

- Using passive sign convention, power can either be positive or negative

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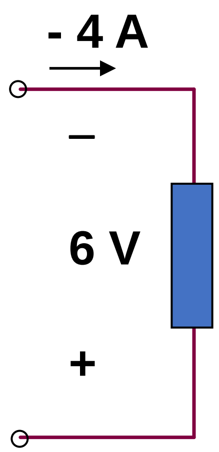
Examples



Using passive sign convention,

$$p = -6 \times -4 = +24\ W$$

Power absorbed

Power an Energy

- Using passive sign convention, power can either be positive or negative

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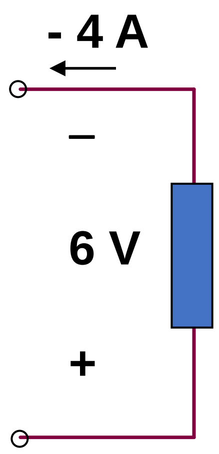
Examples



Using passive sign convention,

p = 6 x - 4 = -24 W

Power supplied

Power an Energy

- Using passive sign convention, power can either be positive or negative

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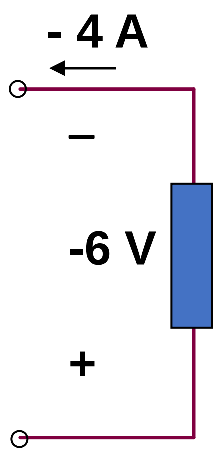
Examples



Using passive sign convention,

$$p = -6 \times -4 = 24\ W$$

Power absorbed

Power an Energy

For any electric circuit ,

$$\sum p = 0$$

Sums of power absorbed and supplied in a circuit always equal to ZERO

Power an Energy

We paid bill to TNB based on the amount of electric energy we consumed

– energy is measured in **Joules (J)**

Since $p = \dfrac{dw}{dt}$, energy absorbed or supplied by an element from t_o to t is :

$$w = \int_{t_o}^{t} p\,dt = \int_{t_o}^{t} vi\,dt$$

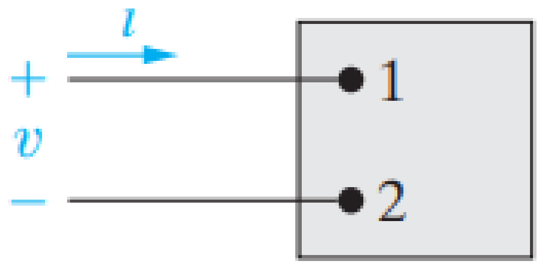


Figure 1.5 ▲ An ideal basic circuit element.

$$i = 0, \qquad t < 0;$$

$$i = 20e^{-5000t}\ \text{A}, \quad t \geq 0.$$

Example 1.3 **Relating Voltage, Current, Power, and En**

Assume that the voltage at the terminals of the element in Fig. 1.5, whose current was defined in Assessment Problem 1.3, is

$$v = 0 \qquad t < 0;$$

$$v = 10e^{-5000t}\ \text{kV}, \qquad t \geq 0.$$

a) Calculate the power supplied to the element at 1 ms.

b) Calculate the total energy (in joules) delivered to the circuit element.

Solution

a) Since the current is entering the + terminal of the voltage drop defined for the element in Fig. 1.5, we use a "+" sign in the power equation.

$$p = vi = (10{,}000e^{-5000t})(20e^{-5000t}) = 200{,}000e^{-10{,}000t} \text{ W}.$$

$$p(0.001) = 200{,}000e^{-10{,}000t(0.001)} = 200{,}000e^{-10}$$

$$= 200{,}000(45.4 \times 10^{-6}) = \boxed{9.0799 \text{ W}}$$

b) From the definition of power given in Eq. 1.3, the expression for energy is

$$w(t) = \int_0^t p(x)dx$$

To find the total energy delivered, integrate the expresssion for power from zero to infinity. Therefore,

$$w_{\text{total}} = \int_0^\infty 200{,}000e^{-10{,}000x}\,dx = \left.\frac{200{,}000e^{-10{,}000x}}{-10{,}000}\right|_0^\infty$$

$$= -20e^{-\infty} - (-20e^{-0}) = 0 + 20 = 20 \text{ J}.$$

Thus, the total energy supplied to the circuit element is 20 J.

Balancing Power

TABLE 1.4 Volatage and current values for the circuit in Fig. 1.7.

Component	v(V)	i(A)
a	120	−10
b	120	9
c	10	10
d	10	1
e	−10	−9
f	−100	5
g	120	4
h	−220	−5

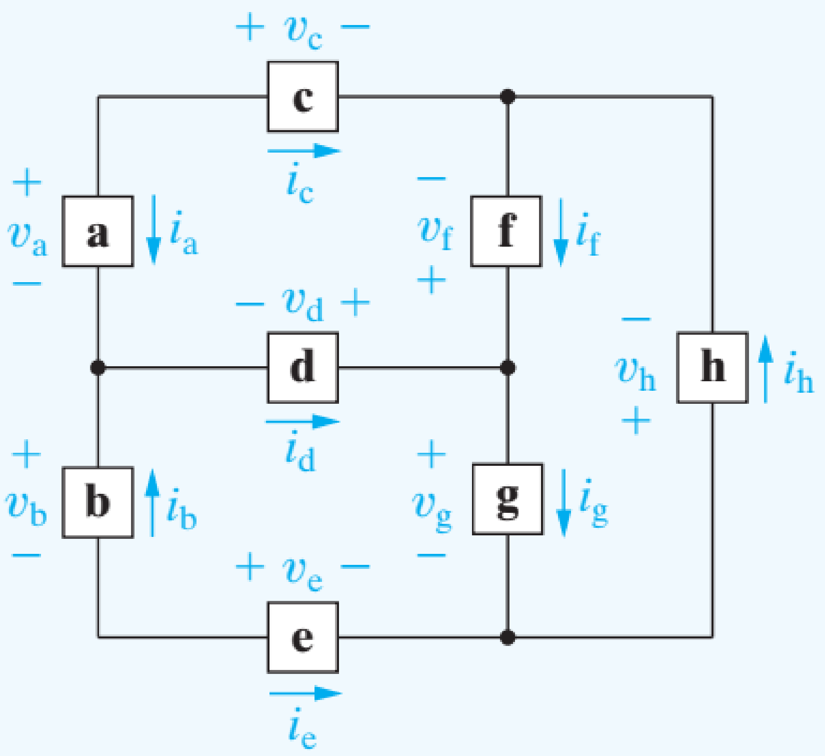


Figure 1.7 ▲ Circuit model for power distribution in a home, with voltages and currents defined.

Balancing Power

$$p_a = v_a i_a = (120)(-10) = -1200 \text{ W}$$

$$p_b = -v_b i_b = -(120)(9) = -1080 \text{ W}$$

$$p_c = v_c i_c = (10)(10) = 100 \text{ W}$$

$$p_d = -v_d i_d = -(10)(1) = -10 \text{ W}$$

$$p_e = v_e i_e = (-10)(-9) = 90 \text{ W}$$

$$p_f = -v_f i_f = -(-100)(5) = 500 \text{ W}$$

$$p_g = v_g i_g = (120)(4) = 480 \text{ W}$$

$$p_h = v_h i_h = (-220)(-5) = 1100 \text{ W}$$

$$p_{\text{supplied}} = p_a + p_b + p_d = -1200 - 1080 - 10 = -2290 \text{ W}$$

$$p_{\text{absorbed}} = p_c + p_e + p_f + p_g + p_h$$

$$= 100 + 90 + 500 + 480 + 1100 = 2270 \text{ W}$$

$$p_{\text{supplied}} + p_{\text{absorbed}} = -2290 + 2270 = -20 \text{ W}$$

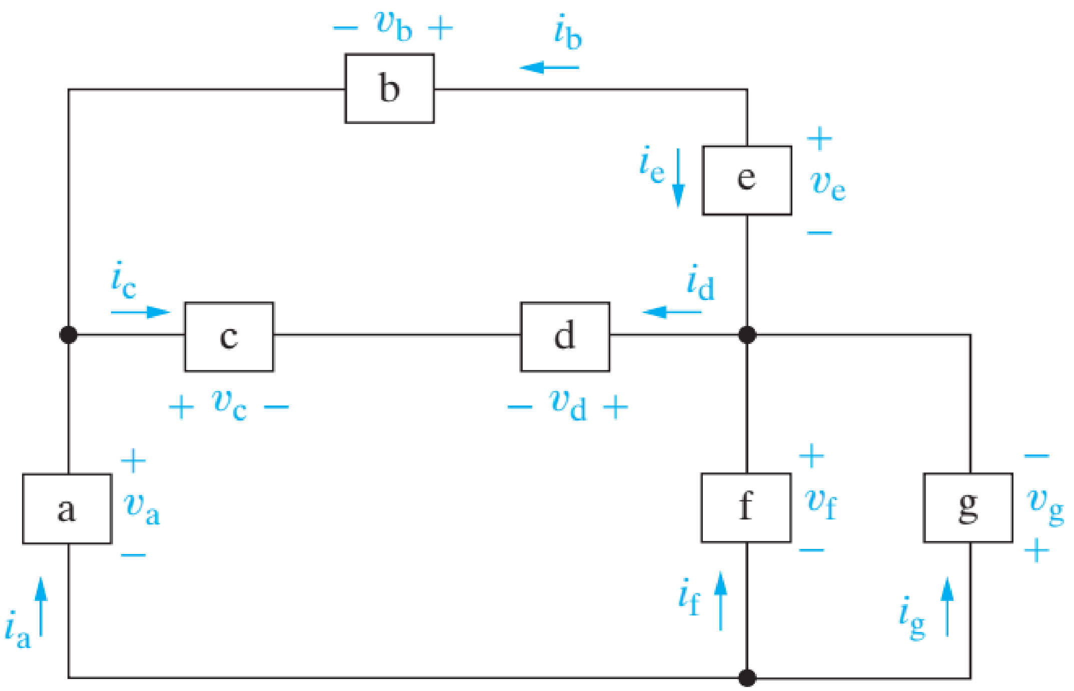
The power is unbalanced due to errors in data
It should be equal ZERO

Solve The Problem

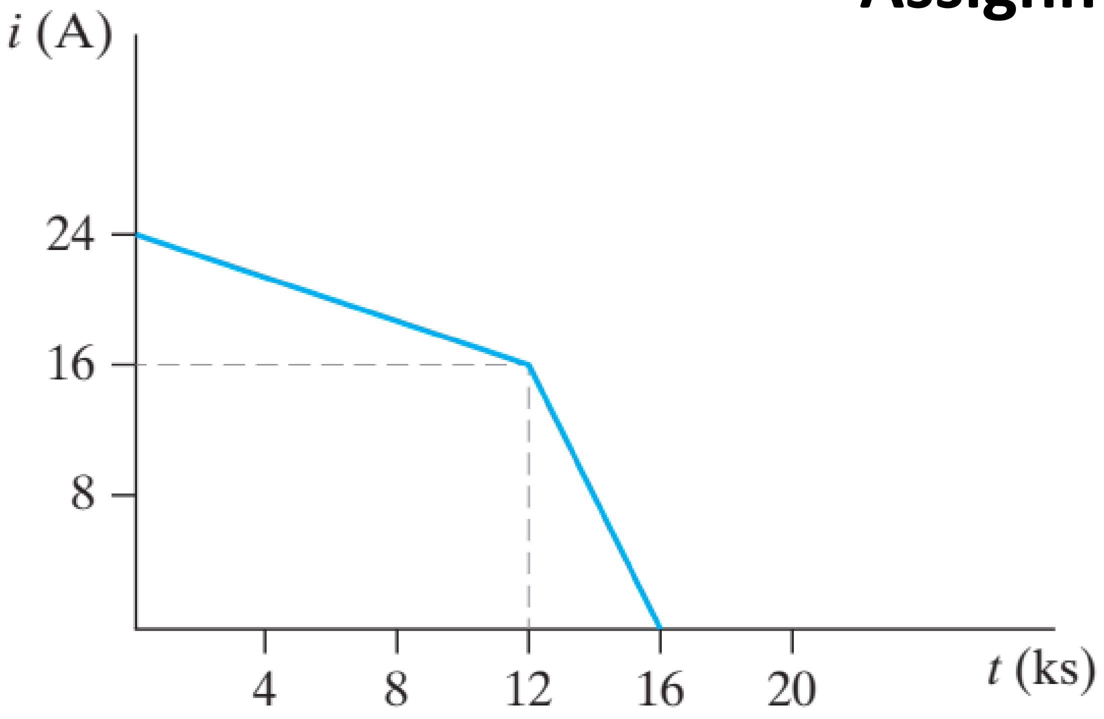
The voltage and power values for each of the elements shown.
a) Show that the interconnection of the elements satisfies the power check.
b) Find the value of the current through each of the elements using the values of power and voltage and the current directions shown in the figure.

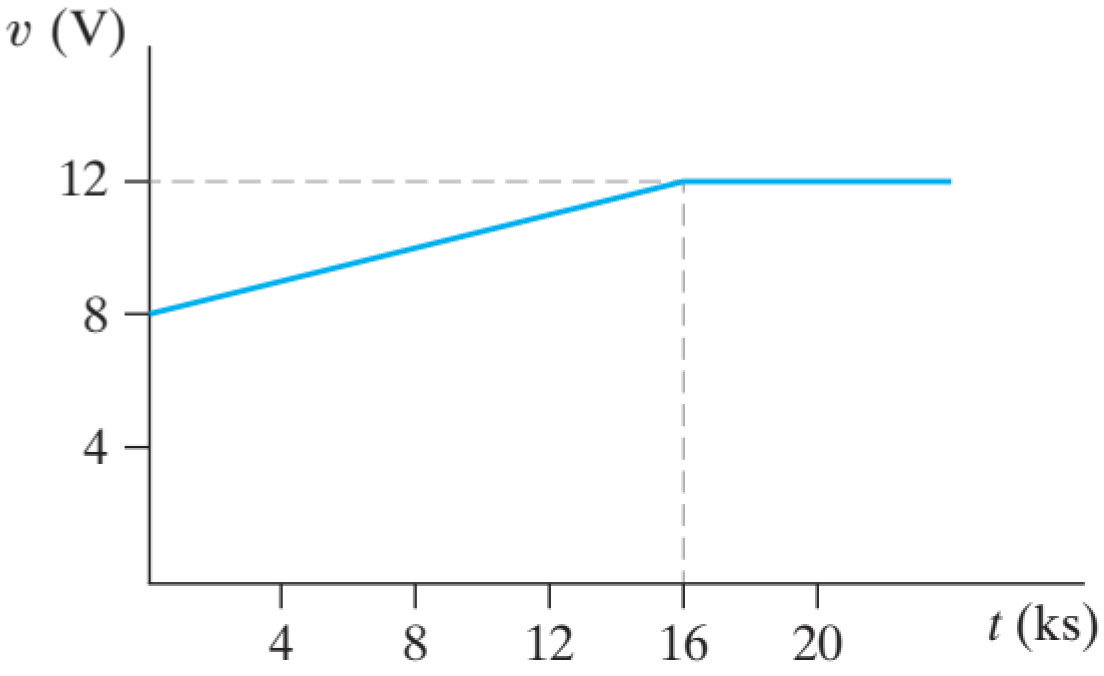
TABLE P1.32

Element	Power (kW)	Voltage (V)
a	0.6 supplied	400
b	0.05 supplied	−100
c	0.4 absorbed	200
d	0.6 supplied	300
e	0.1 absorbed	−200
f	2.0 absorbed	500
g	1.25 supplied	−500



Assignment





The voltage and current at the terminals of an automobile battery during a charge cycle are shown in Figures.

a) Calculate the total charge transferred to the battery.

b) Calculate the total energy transferred to the battery.

c) Find the total energy delivered to the element.


Thank You
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