Basic Electronics

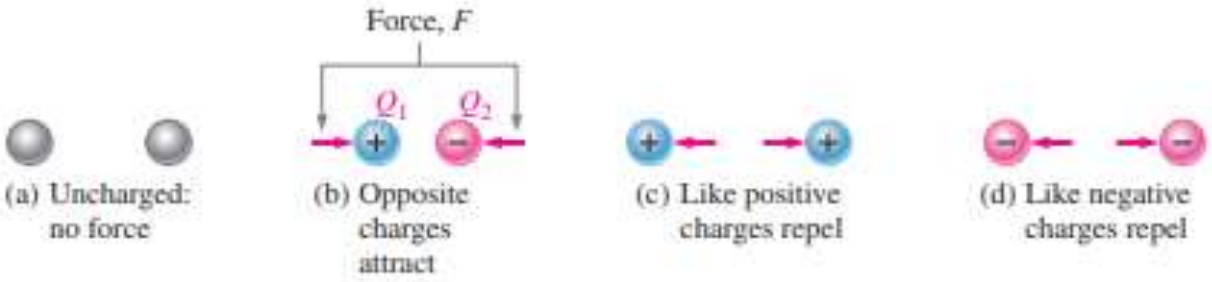
- Electric Charge
- Voltage
- Current
- Resistance
- Current And Voltage Source
- Resistors
- Current Control & Protection

Electric Charge

- is an electrical property of matter that exists because of an excess or deficiency of electrons.
- Charge is symbolized by the letter Q.
- Static electricity is the presence of a net positive or negative charge in a material.

Electric Charge

- Materials with charges of opposite polarity are attracted to each other, and materials with charges of the same polarity are repelled



Electric Field

- A force acts between charges, as evidenced by the attraction or repulsion. This force, called an electric field, is represented by imaginary lines.

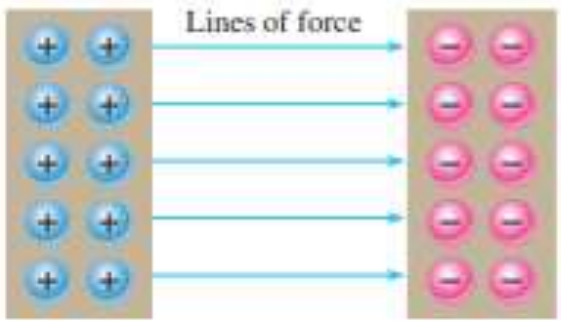


FIGURE 6

Electric field between two oppositely charged surfaces as represented by lines of force.

Coulomb's Law

- A force (F) exists between two point-source charges that is directly proportional to the product of the two charges and inversely proportional to the square of the distance (d) between the charges

Coulomb: The Unit of Charge

- Electrical charge (Q) is measured in coulombs, symbolized by C.
- One coulomb is the total charge possessed by 6.25*10^18 electrons

Coulomb's Law

- A single electron has a charge of 1.6*10^-19 C. The total charge Q, expressed in
- coulombs, for a given number of electrons is stated in the following formula:

$$Q = \frac{\text{number of electrons}}{6.25 \times 10^{18}\ \text{electrons/C}}$$

Coulomb's Law

EXAMPLE 1 How many coulombs do 93.8×10^{16} electrons represent?

Solution

$$Q = \frac{\text{number of electrons}}{6.25 \times 10^{18}\ \text{electrons/C}} = \frac{93.8 \times 10^{16}\ \text{electrons}}{6.25 \times 10^{18}\ \text{electrons/C}} = 15 \times 10^{-2}\ \text{C} = \mathbf{0.15\ C}$$

*Related Problem** How many electrons does it take to have 3 C of charge?

Problems

SECTION 2 Electrical Charge

1. What is the charge in coulombs of the nucleus of a copper atom?
2. What is the charge in coulombs of the nucleus of a chlorine atom?
3. How many coulombs of charge do 50×10^{31} electrons possess?
4. How many electrons does it take to make 80 μC (microcoulombs) of charge?

Voltage

- Voltage, symbolized by V, is defined as energy or work per unit charge.

$$V = W/Q$$

- where V is voltage in volts (V), W is energy in joules (J), and Q is charge in coulombs (C).

The Volt

- The unit of voltage is the volt, symbolized by V.
- One volt is the potential difference (voltage) between two points when one joule of energy is used to move one coulomb of charge from one point to the other.

EXAMPLE 2 If 50 J of energy are required to move 10 C of charge, what is the voltage?

Solution

$$V = \frac{W}{Q} = \frac{50\,\text{J}}{10\,\text{C}} = \mathbf{5\,V}$$

Related Problem How much energy is required to move 50 C from one point to another when the voltage between the two points is 12 V?

Voltage Source

A voltage source provides electrical energy or electromotive force (emf), more commonly known as voltage. Voltage is produced by means of chemical energy, light energy, and magnetic energy combined with mechanical motion.

(a) DC voltage source (b) AC voltage source

Voltage Source

- The Ideal Voltage Source An ideal voltage source can provide a constant voltage for any current required by a circuit. The ideal voltage source does not exist but can be closely approximated in practice.

- For purposes of analysis the ideal source is assumed unless otherwise specified.

Types of DC Voltage Sources

- **Batteries** A battery is a type of voltage source that converts chemical energy directly into electrical energy. As you know, work (or energy) per charge is the basic unit for voltage, and a battery adds energy to each unit of charge.

- A fuel cell is a device that converts electrochemical energy into dc voltage directly. Fuel cells combine a fuel (usually hydrogen) with an oxidizing agent (usually oxygen).

Types of DC Voltage Sources

- In the hydrogen fuel cell, hydrogen and oxygen react to form water, which is the only by-product. The process is clean, quiet, and more efficient than burning.

- Solar Cells The operation of solar cells is based on the photovoltaic effect, which is the process whereby light energy is converted directly into electrical energy.

Problems

SECTION 3 Voltage

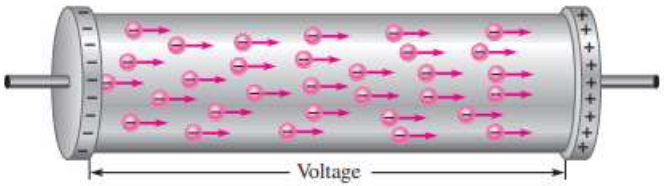
5. Determine the voltage in each of the following cases:
   (a) 10 J/C (b) 5 J/2 C (c) 100 J/25 C
6. Five hundred joules of energy are used to move 100 C of charge through a resistor. What is the voltage across the resistor?
7. What is the voltage of a battery that uses 800 J of energy to move 40 C of charge through a resistor?
8. How much energy does a 12 V battery use to move 2.5 C through a circuit?
9. If a resistor with a current of 2 A through it converts 1000 J of electrical energy into heat energy in 15 s, what is the voltage across the resistor?
10. List four common sources of voltage.
11. Upon what principle is electrical generators based?
12. How does and electronic power supply differ from the other sources of voltage?

Current

- If a voltage is placed across a conductive or semiconductive material, one end becomes positive and the other negative. The repulsive force produced by the negative voltage at the left end causes the free electrons (negative charges) to move toward the right. The attractive force produced by the positive voltage at the right end pulls the free electrons to the right. The result is a net movement of the free electrons from the negative end of the material to the positive end is the Electric Current

Current

- The movement of these free electrons from the negative end of the material to the positive end is the electrical current, symbolized by I.
- Electrical current is the rate of flow of charge.
- Current in a conductive material is determined by the number of electrons (amount of charge) that flow past a point in a unit of time



Current

$$I = Q/t$$

- where I is current in amperes (A), Q is charge in coulombs (C), and t is time in seconds (s).
- One ampere (1 A) is the amount of current that exists when a number of electrons having a total charge of one coulomb (1 C) move through a given cross-sectional area in one second (1 s)

Current

$$I = Q/t$$

EXAMPLE 3 Ten coulombs of charge flow past a given point in a wire in 2 s. What is the current in amperes?

Solution

$$I = \frac{Q}{t} = \frac{10\,\text{C}}{2\,\text{s}} = \mathbf{5\,A}$$

Related Problem If there are 8 A of current through the filament of a lamp, how many coulombs of charge move through the filament in 1.5 s?

Current Source

- The Ideal Current Source As you know, an ideal voltage source can provide a constant voltage for any load. An ideal current source can provide a constant current in any load.
- Just as in the case of a voltage source, the ideal current source does not exist but can be approximated in practice.

(a) Symbol

Practical Current Sources

- Power supplies are normally thought of as voltage sources because they are the most common type of source in the laboratory. However, current sources are another type of energy source. Current sources may be "stand-alone" instruments or may be combined with other instruments, such as a voltage source, DMM, or function generator.

Problems

SECTION 4 Current

13. A certain current source provides 100 mA to a 1 kΩ load. If the resistance is decreased to 500 Ω, what the current in the load?

14. Determine the current in each of the following cases:

(a) 75 C in 1 s (b) 10 C in 0.5 s (c) 5 C in 2 s

15. Six-tenths coulomb passes a point in 3 s. What is the current in amperes?

16. How long does it take 10 C to flow past a point if the current is 5 A?

17. How many coulombs pass a point in 0.1 s when the current is 1.5 A?

18. 5.74×10^{17} electrons flow through a wire in 250 ms. What is the current in amperes?