Electric Current

Learning Target

14.3	I can define, analyze, and solve problems involving current electricity.

Key Concepts

- 2 Kinds of charge, positive and negative
- Conservation of charge
- Conductors vs. insulators
- Charging by conduction vs. induction
- Grounding
- Coulomb's Law

$$F = K\frac{q_A q_B}{r^2}$$

Electric Field Strength

Definition:
The **force per unit charge** experienced by a **small positive test charge** placed in the field.

$$E = \frac{F}{Q}$$

Units: NC^{-1}

Gravitational Field Strength

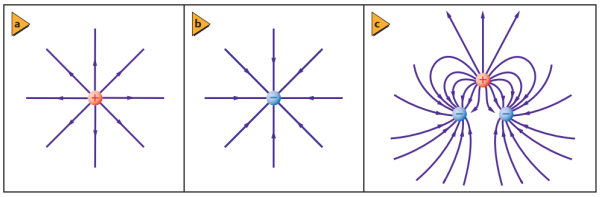
Definition:
The **force per unit mass** experienced by a **small test mass** placed in the field.

$$g = \frac{F}{m}$$

Units: NKg^{-1}

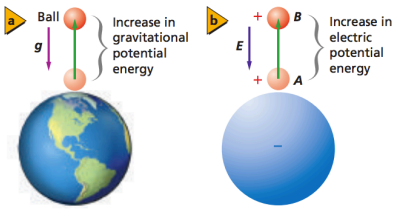
The Electric Field

Electric field lines provide a picture of the electric field. They are directed away from positive charges and toward negative charges. They never cross, and their density is related to the strength of the field.



Energy and Electric Potential

Work is needed to move an object against the force of gravity and also against the electric force. In both cases, the potential energy of the object is increased.



Energy and Electric Potential

The work done per unit charge in moving a charge between two points in an electric field is known as the electric potential difference, (ΔV).

$$\Delta V = \frac{W}{q} = \frac{\Delta U_e}{q}$$

Energy and Electric Potential

Vector of Scalar

Units $\frac{J}{C}$ = Volt (V)

Relationship

W → Direct Prop.
q → Inv. Prop.

$$\Delta V = \frac{W}{q}$$

Electric Current

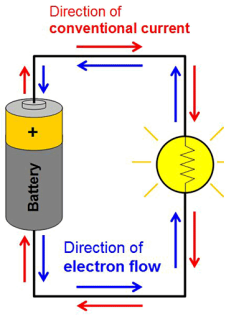
Electric current is the flow of charge.

Electric currents flow from high electric potential to low electric potential. And the greater the difference between the high and low potential, the more current that flows!

Electric Current

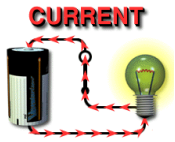
Conventional Current assumes that current flows out of the positive terminal, through the circuit and into the negative terminal of the source.

Electron Current is what actually happens and electrons flow out of the negative terminal, through the circuit and into the positive terminal of the source.



Electric Current

Electric current (I) can be calculated by finding the total amount of charge (Δq), in Coulombs, which passes a specific point in a given time (t).



$$I = \frac{\Delta q}{\Delta t}$$

Electric Current

Vector of Scalar

Units $\frac{C}{s}$ = ampere (A)

Ampere

Relationship

$$I = \frac{\Delta q}{\Delta t}$$

Resistance

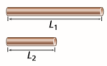
We describe a material's ability to conduct electric charge as **conductivity**.

In similar fashion, we describe a material's ability to resist the movement of electric charge using **resistance**. Units of resistance are ohms (Ω).

R

Resistance

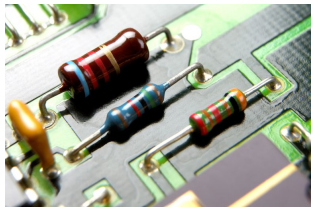
Table 22-1
Changing Resistance

Factor	How resistance changes	Example
Length	Resistance increases as length increases.	$R_{L1} > R_{L2}$ 
Cross-sectional area	Resistance increases as cross-sectional area decreases.	$R_{A1} > R_{A2}$ 
Temperature	Resistance increases as temperature increases.	$R_{T1} > R_{T2}$ 
Material	Keeping length, cross-sectional area, and temperature constant, resistance varies with the material used.	*R* increases: Platinum, Iron, Aluminum, Gold, Copper, Silver

Resistance

A material's ability to resist the movement of electric charge is its **resistivity**, symbolized with the Greek letter rho (ρ).

$$R = \frac{\rho \ell}{A}$$



Resistance

Resistance (R)

For any given temperature, we can calculate an object's electrical resistance, in ohms, using the following formula:

$$R = \frac{\rho \ell}{A}$$

- R is the resistance of the object, in ohms (Ω)
- rho (ρ) is the resistivity of the material the object is made out of, in ohm*meters (Ω•m)
- ℓ is the length of the object, in meters
- A is the cross-sectional area of the object, in meters squared.

Resistance

Vector of Scalar

Units

Relationship

$$R = \frac{\rho \ell}{A}$$

UNIT 14: IN-CLASS PROBLEMS

5. How much work is required to move a charge of 2.20 x 10^{-6} C from point A to point B, given that the change in electric potential between those points is 24.0 V?
6. The disk drive in a portable CD player is connected to a battery that supplies it with a current of 0.22 A. How many electrons pass through the disk drive in 4.5 s?
7. A 3.50-meter length of wire has a cross-sectional area of 3.14×10^{-6} m^2. At 20° Celsius, the wire has a resistance of 0.0625 Ω. Determine what material is most likely in this wire.

Resistivities at 20°C

Material	Resistivity (Ω•m)
Aluminum	2.82×10^{-8}
Copper	1.72×10^{-8}
Gold	2.44×10^{-8}
Nichrome	$150. \times 10^{-8}$
Silver	1.59×10^{-8}
Tungsten	5.60×10^{-8}

UNIT 14: IN-CLASS PROBLEMS

5. How much work is required to move a charge of 2.20 x 10^{-6} C from point A to point B, given that the change in electric potential between those points is 24.0 V?

$q = 2.20 \times 10^{-6}$ C

$\Delta V = 24.0$ V

$W = ?$

$\Delta V = \frac{W}{q}$

$W = 5.28 \times 10^{-5}$ J

UNIT 14: IN-CLASS PROBLEMS

6. The disk drive in a portable CD player is connected to a battery that supplies it with a current of 0.22 A. How many electrons pass through the disk drive in 4.5 s?

$I = \frac{q}{t}$ $q = It = 0.99\,C$

$e = 1.60 \times 10^{-19}\,C$

$\frac{0.99}{e} = 6.2 \times 10^{18}$ electrons

UNIT 14: IN-CLASS PROBLEMS

7. A 3.50-meter length of wire has a cross-sectional area of $3.14 \times 10^{-6}\ m^2$. At 20° Celsius, the wire has a resistance of 0.0625 Ω. Determine what material is most likely in this wire.

Resistivities at 20°C	
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$R = \frac{\rho l}{A}$

$\rho = \frac{R \cdot A}{l} = 5.61 \times 10^{-8}\ \Omega \cdot m$

Problems (21-32)