PhyzExamples: Electricity

Physical Quantities • Symbols • Units • Brief Definitions

Charge • *q or Q* • coulomb [*KOO lom*]: C • A characteristic of certain fundamental particles.

Elementary Charge • $e = 1.6 \times 10^{-19}$ C • The *quantity* of charge carried by protons and electrons.

Electric Field • *E* • newton per coulomb: N/C or volt per meter: V/m • The electric force experienced by each unit of charge in a particular location.

Coulomb Constant • $k = 9 \times 10^{9}$ N·m^2/C^2.

Masses • Electron: 9.11×10^{-31} kg • Proton: 1.67×10^{-27} kg • Neutron: 1.67×10^{-27} kg

Current • *I* • coulomb per second: C/s or ampere: A • The rate at which electric charge flows.

Voltage • *V* or $\mathcal{E}$ • joule per coulomb: J/C or volt: V • Electric potential energy per unit of charge; electric "oomph."

Resistance • *R* • volt per amp: V/A or ohm: Ω • A measure of the obstruction to flow of electric charge that a *body* possesses.

Power • *P* • watt: W • The rate at which energy is transferred in an electric circuit.

Equations

$F = kq_1q_2/R^2$ • Coulomb's Law • *electric force = coulomb constant · charge on one body · charge on another body / square of the distance between the charged bodies*

$E = F/q$ • *electric field = electric force / charge*

$I = q/t$ • *current = charge / time*

$I = V/R$ or $\mathcal{E}/R$ • Ohm's Law • *current = voltage / resistance*

$P = IV$ or $I\mathcal{E}$ • Joule's Law • *power = current · voltage*

$P = I^2R$ • *power = square of current · resistance*

$P = V^2/R$ or $\mathcal{E}^2/R$ • *power = square of voltage / resistance*

Smooth Operations Examples

1. What is the force on a +2.3 μC charge that lies 3.7 m to the left of a –5.1 μC charge?

1. $q_1 = +2.3 \times 10^{-6}$ C $q_2 = -5.1 \times 10^{-6}$ C
R = 3.7 m F = ?
$F = kq_1q_2/R^2$
$F = 9 \times 10^9$ N·m^2/C^2 $(+2.3 \times 10^{-6}$ C) · $(-5.1 \times 10^{-6}$ C)/(3.7 m)^2
F = –0.0077 N ("–" indicates attraction)

2. How far is a +4.5 mC from a –8.2 mC if there is a force of 13 N between them?

2. $q_1 = +4.5 \times 10^{-3}$ C $q_2 = -8.2 \times 10^{-3}$ C
F = 13 N R = ?
Note: the force is attractive so use –13 N
$F = kq_1q_2/R^2$
$R = \sqrt{(kq_1q_2/F)}$
$R = \sqrt{[9 \times 10^9}$ N·m^2/C^2 $(+4.5 \times 10^{-3}$ C) $(-8.2 \times 10^{-3}$ C)/(–13 N)]
R = 160 m

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3. A droplet of ink in an inkjet printer has a charge of 370 nC. It is directed by an electric force of 82 mN as it passes through the print head's electric field. What is the strength of the electric field in the print head?

3. $q = 370 \times 10^{-9}$ C $F = 82 \times 10^{-6}$ N
E = F/q
E = 82×10^{-6} N / 370×10^{-9} C
E = 220 N/C

4. What is the current in a wire if 15.7 C of charge move past a point in the wire every 2.3 s?

4. q = 15.7 C t = 2.3 s I = ?
I = q/t
I = 15.7 C / 2.3 s
I = 6.8 A

5. A current of 0.82 A passes through a 47-Ω resistor. What is the potential difference across the resistor?
(The question is asking for the voltage.)

5. I = 0.82 A R = 47 Ω V = ?
I = V/R
V = IR
V = 0.82 A · 47 Ω
V = 39 V

6. If a 100-W stereo system is plugged into the 120-V line voltage used in US homes, how much current does it draw?

6. P = 100 W V = 120 V I = ?
P = IV
I = P/V
I = 100 W / 120 V
I = 0.83 A

7. What is the resistance of a 1500-W hair dryer that draws 13 A of current?

7. P = 1500 W I = 13 A R = ?
$P = I^2R$
$R = P/I^2$
R = 1500 W / $(13$ A$)^2$
R = 8.9 Ω

8. An appliance with a resistance of 36 Ω operates at 9.0 V. At what rate does it dissipate energy? (That is, what's the power?)

8. R = 36 Ω V = 9.0 V P = ?
$P = V^2/R$
P = $(9.0$ V$)^2$ / 36 Ω
P = 2.3 W