VERSION 2.0
Feb 19-26 Concepts – azj

Physical Sciences 3
Lectures 5 and 6 – February 20, 2008 – Voltage, Current, Resistance, Capacitance
Reading for Understanding: Chapter 24 and Chapter 26 s1-3

ELECTRIC CURRENT, I

the amount of charge, Q going through a cross-section of a conductor

$I = \frac{Q}{t}$

measured in Amperes, A
units $\frac{C}{s} = A$

(in most metals, e- are free to move around.)

relationship →

OHM'S LAW

Current, I, flowing through a conductor is proportional to the potential difference ΔV between the ends.

$\Delta V = RI$ (units: volts)

where R is a proportionality constant called RESISTANCE

$[R] = \frac{V}{A}$ = ohm, Ω

→ depends on the length, l the cross sectional area, A as well as temperature and pressure of the material.

∴ $R = \rho \frac{l}{A}$ (units: ohms)

where ρ is called RESISTIVITY - a material constant, independent of shape.

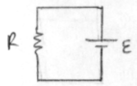
EMF, Electromotive Force

not *really a force* but a device that converts one type of energy to another is a source of emf, like a battery ⊣⊢

ability to create a potential diff

in practice →

put our chosen emf, a battery ⊣⊢ call ε into a circuit connected to a resistor, R



current should be
$\varepsilon = IR$

* BUT batteries also have their own internal resistance, called "r" that decreases the available electrical energy

leads to →

ELECTRIC POWER

recall that power is energy per unit time.

- in a circuit, t seconds later, charge ($Q = It$) moves across ΔV losing energy $U = Q\Delta V$

∴

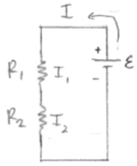
$P = \frac{U}{t} = \frac{Q\Delta V}{t} = I\Delta V$

measured in watts

$P = IV = I^2R = V^2/R$

RESISTORS

① in series, current flow is the same through both resistors

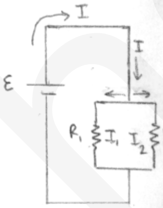


$I = I_1 = I_2$

voltages add across resistors:
$\varepsilon = V_1 + V_2$

finding the equivalent resistance:
$R_1 + R_2 = R_{equiv}$

② in parallel, voltage across each resistor is the same



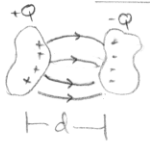
$\varepsilon = V_1 = V_2$

currents add across resistors:
$I = I_1 + I_2$

finding the equivalent resistance:
$1/R_1 + 1/R_2 = 1/R_{TOT}$

NEW TOPIC

CAPACITORS



consists of two conducting objects separated by small distance, d.

purpose is to store electric charge, Q

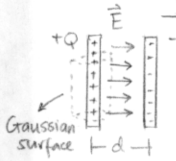
also need an emf to create a potential difference - still a battery ⊣⊢

$Q = C\Delta V$

where C is called CAPACITANCE measured in Farads (F) common unit is μF.

consider ↓

PARALLEL-PLATE CAPACITOR



A, area of plate

consider Gaussian surface around one plate... $\Phi_E = \frac{Q_{in}}{\epsilon_0} = \frac{Q\delta}{\epsilon_0 A} = \vec{E}\delta$

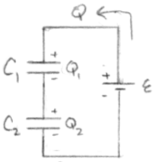
$\vec{E} = \frac{Q}{\epsilon_0 A}$ $\Delta V = \frac{Qd}{\epsilon_0 A}$ $C = \frac{\epsilon_0 A}{d}$

$\kappa > 1$ IF put a dielectric material in between plates (width d) then...

$\vec{E} = \frac{Q}{\kappa\epsilon_0 A}$ $\Delta V = \frac{Qd}{\kappa\epsilon_0 A}$ $C = \frac{\kappa\epsilon_0 A}{d}$

CAPACITORS ⊣⊢

① in series, charge is the same on both capacitors

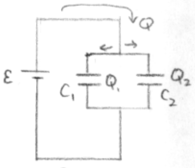


$Q = Q_1 = Q_2$

potentials add across capacitors:
$\varepsilon = V_1 + V_2$

finding the equivalent capacitance
$1/C_{TOT} = 1/C_1 + 1/C_2$

② in parallel, potential across each capacitor is the same



$V_1 = V_2 = \varepsilon$

charge adds across capacitors
$Q = Q_1 + Q_2$

finding equivalent capacitance:
$C_{TOT} = C_1 + C_2$

ENERGY STORAGE

$dW = dq\,\Delta V = dq\,\frac{q}{C}$ integrate

$W = U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$

measured in joules