



Crack Notes [Physics 7] Electricity & Magnetism

Charge (q, Coulombs)

Coulomb's law: force between two charges $F = k \frac{q_1 q_2}{r^2}$

Remember that like charges repel, opposite charges attract

Center of charge: can treat entire collection of charges as single charge at that point

Electric Field (E, N/C or V/m)

Field lines: point in direction of field, or from (+) to (-) charges

-> Denser = higher field strength

Force due to electric field: $F = qE$

Potential energy due to position in electric field: $U = qEd$

Point charge: $E = k \frac{q}{r^2}$, $U = k \frac{q_1 q_2}{r}$

Voltage/Potential (V, Volts or J/C)

How much potential work an electric field must do to move a charge a certain distance

Stronger electric field = more potential for work

More distance = more work

so $V = Ed$, for a point charge $V = k \frac{q}{r}$

Note that $U = qV$, or for a specific charge its potential energy is related to the voltage

Equipotential surfaces: perpendicular to field lines, moving a charge along these surfaces requires no work

Charge Movement

Conductor: electrons can move easily i.e. metals

Resistors/insulators: electrons can't really move i.e. diamond, glass

Induction: charged things can cause charge to move in other things

Current (I, Amps or C/s)

Defined as opposite direction of flow of electrons (= flow of positive charge)



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Batteries supply an *electromotive force* or voltage across two points

Resistors

Resistance (R , Ohms Ω): how much a substance resists charge flow

$$\rightarrow R = \rho \frac{L}{A}, \rho \text{ is resistivity}$$

Capacitors

Stores energy by separating positive + negative charges

Capacitance (C , Farads F): how much energy the capacitor can potentially store

Formula: $C = \frac{Q}{V}$, so high capacitance = more charge stored at lower voltage

Parallel plate capacitor: $C \propto K \frac{A}{d}$

$$\text{Energy stored in capacitor: } U = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} \frac{Q^2}{C}$$

Dielectric constant: material between plates on capacitor, some material can give capacitor more potential for storing energy

\rightarrow Vacuum has $K = 1$, if a capacitor has $K = 4$ then the capacitor has 4 times the capacitance so can store 4 times the amount of energy

Circuits

Ohm's Law: $V = iR$

Kirchoff's First Law: amount of current flowing into any point = amount of current flowing out

Kirchoff's Second Law: sum of voltage changes around a path in a closed circuit = 0

Series: current goes into one, then the other

$$\rightarrow R_{eff} = R_1 + R_2 + \dots, \frac{1}{C_{eff}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

Parallel: current splits, part of current goes into one, other part goes into other

$$\rightarrow \frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots, C_{eff} = C_1 + C_2 + \dots$$

Power

Either power circuit can supply, or power dissipated by resistor; $P = iV = i^2R = V^2 / R$



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AC Current

Oscillates sinusoidally

$$V_{max} = \sqrt{2}V_{rms}, i_{max} = \sqrt{2}i_{rms}, \text{ so } P_{max} = 2P_{rms}$$

Magnetism

Magnetic fields are created by magnetic dipoles in the material

-> Can also be created by a changing electric field

Symbol is B, units are tesla (T)

Field lines go from north to south

Created by wire: $B = \frac{\mu_0 i}{2\pi r}$, circles around wire (right hand rule tells direction)

Magnetic force (created by moving charge): $F = qvB \sin \theta$

-> Direction perpendicular to both charge velocity AND magnetic field

-> Find direction using RHR

APPLICATIONS:

Particle moving in magnetic field: set force equal to centripetal force to find v

We can also find whether wires are attracted to or repel each other

Faraday's law: changing magnetic field creates an electric field

-> So changing magnetic field creates a current

-> Current always goes AGAINST change in magnetic field

-> Loop of wire: if magnetic field decreases, current will be created to increase it back