Física 2 – Anotações: Teste

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1 Capacitance

Capacitance

1.1 Definition

$$C = Q/V$$

1.2 Capacitance on different capacitors

(i) Of an isolated spherical conductor

$$C = 4\,\pi\,\varepsilon_0\,R$$

(ii) Of a parallel-plate capacitor

$$C = \varepsilon_0\,A/d$$

(iii) Of a cylindrical capacitor

$$C = \frac{2\,\pi\,\varepsilon_0\,L}{\ln(R_2/R_1)}$$

1.3 Energy stored in a capacitor

$$U = \frac{Q\,V}{2} = \frac{Q^2}{2\,C} = \frac{C\,V^2}{2}$$

1.4 Energy density of an electric field

$$u_e = \varepsilon_0\,E^2/2$$

1.5 Equivalent Capacitance

(i) Parallel

$$C_{eq} = \sum_{i=1}^{n} C_i$$

(ii) Serie

$$C_{eq}^{-1} = \sum_{i=1}^{n} C_i{}^{-1}$$

1.6 Electric field inside

$$E = E_0/\kappa$$

1.7 Effect on capacitance

$$C = \kappa\,C_0$$

1.8 Permittivity ε

$$\varepsilon = \kappa\,\varepsilon_0$$

2 Electric Current and Direct-Current Circuits

Electric Current

2.1 Definition

$$I = \frac{\Delta Q}{\Delta T}$$

2.2 Drift Velocity

$$I = q\,n\,A\,v_d$$

2.3 Current Density

$$\vec{J} = q\,n\,\vec{v_d}$$

Resistance

2.4 Definition

$$R = V/I$$

2.5 Resistivity ρ

$$R = \rho\,L/A$$

2.6 Temperature coefficient of resitivity (α)

$$\alpha = \frac{\rho/\rho_0 - 1}{T - T_0}$$

2.7 Ohm's Law

$$V = I\,R$$

2.8 Power

(i) Suplied by a device or segment

$$P = I\,V$$

(ii) Delivered to a resistor

$$P = I\,V = I^2\,R = V^2/R$$

2.9 Emf

$$P = I\,\mathcal{E}$$

Battery

2.10 Terminal Voltage

$$V_a - V_b = \mathcal{E} - I\,r$$

2.11 Total energy stored

$$E_{stored} = Q\,\mathcal{E}$$

(i) Equivalent Resistance

(ii) Series

$$R_{eq} = \sum_{i=1}^{n} R_i$$

(iii) Parallel

$$R_{eq}^{-1} = \sum_{i=1}^{n} R_i^{-1}$$

2.12 Kirchhoff's Rules

1. When any closed loop is traversed, the algebraic sum of the changes in potential around the loop must equal zero.
2. At any junction (branch point) in a circuit where the current can divide, the sum of the currents into the junction must equal the sum of the currents out of the junction.

Disharging the Capacitor

2.13 Charge the capacitor

$$Q(t) = Q_0\,\exp(-t/RC) = Q_0\,\exp(-t/\tau)$$

2.14 Current in a circuit

$$I = -\frac{\mathrm{d}Q}{\mathrm{d}t} = \frac{V_0}{R}\exp(-t/RC) = I_0\,\exp(-t/\tau)$$

2.15 Time constant

$$\tau = RC$$

Charging a Capacitor

2.16 Charge on the capacitor

$$Q = C\,\mathcal{E}\,\left(1 - \exp(-t/RC)\right) = Q_f\,\left(1 - \exp(-t/\tau)\right)$$

3 The Magnetic Field

3.1 Magnetic Force

(i) On a moving charge

$$\vec{F} = q\,\vec{v} \times \vec{B}$$

(ii) On a current element

$$\mathrm{d}\vec{F} = I\,\mathrm{d}\vec{l} \times \vec{B}$$

3.2 Unit of the magnetic field (Tesla)

$$\mathrm{T} = 10^4\,\mathrm{G}$$

Motion of Point Charges

3.3 Newton's Second Law

$$q\,v\,B = m\,v^2/r$$

3.4 Cyclotron

(i) Period

$$T = \frac{2\,\pi\,m}{q\,B}$$

3.5 Frequency

$$f = T^{-1} = \frac{q\,b}{2\,\pi\,m}$$

3.6 Velocity Selector

$$v = E/B$$

A velocity selector consists of crossed electric and magnetic fields so that the electric and magnetic forces balance for a particle moving with speed v.

Current Loops

3.7 Magnetic dipole moment

$$\vec{\mu} = N\,I\,A\,\hat{n}$$

3.8 Torque

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

3.9 Potential Energy of a magnetic dipole

$$U = -\vec{\mu} \cdot \vec{B}$$

3.10 Net force

The net force on a current loop in a uniform magnetic field is zero.

The Hall Effect

When a conducting strip carrying a current is placed in a magnetic field, the magnetic force on the charge carriers causes a separation of charge called the Hall effect.

3.11 Hall voltage

$$V_H = E_H\,w = v_d\,B\,w = \frac{|I|}{nte}B$$

3.12 Conventional von Klitzing constant (definition of ohm)

$$R_{k-90} = 25\,812.807\,6\,\Omega\ \text{(exact)}$$

4 Sources of the magnetic field

(i) Magnetic Constant (μ_0)

$$\mu_0 = 4\,\pi\,10^{-7\,\mathrm{T\,m/A}} = 4\,\pi\,10^{-7\,\mathrm{N/A^2}}$$

4.1 Magnetic Field ($\vec{B}$)

(i) Due to a moving point charge

$$\vec{B} = \frac{\mu_0}{4\,\pi}\frac{q\,\vec{v}\times\hat{r}}{r^2}$$

(ii) Due to a current element (Biot-Savart law)

$$\mathrm{d}\vec{B} = \frac{\mu_0}{4\,\pi}\frac{I\,\mathrm{d}\vec{l}\times\hat{r}}{r^2}$$

(iii) On the axis of a current loop

$$B_z = \frac{\mu_0}{4\,\pi}\frac{2\,\pi\,R^2\,I}{(z^2+R^2)^{3/2}}$$

(iv) Inside a long solenoid (far from the edges)

$$B_Z = \mu_0\,n\,I$$

Where n is the number of turns per unit length

(v) Inside the tubs of a tight wound toroid

$$B = \frac{\mu_0}{2\,\pi}\frac{N\,I}{r}$$

(vi) Due to a straight wire segment

$$B = \frac{\mu_0}{4\,\pi}\frac{I}{R}\Delta\sin(\theta)$$

where R is the perpendicular distance to the wire and θ_1 and θ_2 are the angles subtended at the field point by the ends of the wire.

(vii) Due to a long straight wire

$$B = \frac{\mu_0}{4\,\pi}\frac{I}{R}\left(\sin\left(\frac{\pi}{2}\right) - \sin\left(-\frac{\pi}{2}\right)\right) = \frac{\mu_0}{4\,pi}\frac{I}{R}2$$

4.2 Gauss's Law for Magnetism

$$\phi_{m,net} = \oint_S \vec{B}\cdot\hat{n}\,\mathrm{d}A = \oint_S B_n\,\mathrm{d}A = 0$$

4.3 Ampère's Law

$$\oint_C \vec{B}\cdot\mathrm{d}\vec{l} = \oint_C B_t\,\mathrm{d}l = \mu_0\,I_C$$

- Where C is any closed curve
- Cant be used where I varies

$\vec{B}$ in Magnetic Materials

$$\vec{B} = \vec{B}_{app} + \mu_0\,\vec{M}$$

4.4 Magnetic susceptibility (χ_m)

$$\vec{M} = \chi_m\frac{\vec{B}_{app}}{\mu_0}$$

4.5 Relative Permeability

$$\vec{B} = K_m\,\vec{B}_{app} \quad \text{Where } K_m = 1 + \chi_m$$

Atomic Magnetic Moments

$$\vec{\mu} = \frac{q}{2\,m}\vec{L}$$

Where $\vec{L}$ is the angular momentum of the particle

4.6 Bohr magneton

$$\mu_B = \frac{e\hbar}{2\,m_e} = 9.27 * 10^{-24}\,\mathrm{A\,m^2} =$$
$$= 9.27 * 10^{-24}\,\mathrm{J/T} = 5.79 * 10^{-5}\,\mathrm{eV/T}$$

4.7 Due to orbital motion of an eletron

$$\vec{\mu}_l = -\mu_B\frac{\vec{L}}{\hbar}$$

4.8 Due to electron spin

$$\vec{\mu}_s = -2\,\mu_B\frac{\vec{S}}{\hbar}$$

Paramagnetism

4.9 Curie's Law (weak fields)

$$M = \frac{\mu\,B_{app}}{3\,k\,T}M_s$$

5 Magnetic Induction

Magnetic Flux ϕ_m

5.1 Units

$$1\,\mathrm{Wb} = 1\,\mathrm{T\,m^2}$$

5.2 General Definition

$$\phi_m = \int_S \vec{B} \cdot \hat{n}\ \mathrm{d}A$$

(i) Uniform field, flat surface bounded by coil of N turns

$$\phi_m = N\,B\,A\,\cos\theta$$

- *A* Flat surface bounded by a single turn

5.3 Due to a current in a circuit

$$\phi_m = L\,I$$

5.4 Due to a current in two circuit

$$\phi_{m,1} = L_1\,I_1 + M\,I_2$$
$$\phi_{m,2} = L_2\,I_2 + M\,I_1$$

EMF

5.5 Faraday's Law

Includes both induction and motional emf

$$\mathcal{E} = -\frac{\mathrm{d}\phi_m}{\mathrm{d}t}$$

(i) Induction

Time-varying magnetic field, C stationary

$$\mathcal{E} = \oint_C \vec{E} \cdot \mathrm{d}\vec{l}$$

(ii) Rod moving perpendicular to both its length and $\vec{B}$

$$|\mathcal{E}| = v\,B\,l$$

(iii) Self inducted (back emf)

$$\mathcal{E} = -L\,\frac{\mathrm{d}I}{\mathrm{d}t}$$

5.6 Lenz's Law

The induced emf and induced current are in such a direction as to oppose, or tend to oppose, the change that produces them.

Inductance

5.7 Units and constants

$$1\,\mathrm{H} = 1\,\mathrm{Wb/A} = 1\,\mathrm{T\,m^2/A}$$
$$\mu_0 = 4\,\pi * 10^{-7}\,\mathrm{H/m}$$

5.8 Formulas

(i) Self Inductance

$$L = \phi_m / I$$

(iii) Mutual inductance

$$M = \phi_{m,2,1}/I_1 = \phi_{m,1,2}/I_2$$

(ii) Self Inductance of a solenoid

$$L = \mu_0\,n^2\,A\,l$$

Magnetic Energy

5.9 Energy stored in an inductor

$$U_m = L\,I^2/2$$

5.10 Energy density in a magnetic field

$$u_m = \frac{B^2}{2\,\mu_0}$$

RL Circuits

5.11 Potential difference across an inductor

$$\Delta V = \mathcal{E} - I\,r = -L\,\frac{\mathrm{d}I}{\mathrm{d}t} - I\,r$$