Review for Celebration #2

Review for Test #2

Chapter 26: Current + Resistance

current $\boxed{i = \frac{dq}{dt}}$ units of $i \rightarrow$ amp (A) $\boxed{1\,A = 1\,C/s}$

conventional current $\Rightarrow$ flow of hypothetical + charge from + to − terminal of battery

in reality, electrons flow in opposite direction

always applies

$\boxed{i = \int \vec{J} \cdot d\vec{A}}$ current density $\boxed{J = i/A}$ $[J] = A/m^2$

applies if i is uniform and parallel to $d\vec{A}$

drift speed $\boxed{V_d = \frac{i}{nAe}}$

$V_d = J/ne \longrightarrow \boxed{\vec{J} = (ne)\vec{V}_d}$

definition of resistance $\boxed{R = V/i}$ units of $R \longrightarrow$ ohm (Ω)

$\boxed{1\,\Omega = 1\,V/A}$

resistivity $\boxed{\rho = E/J}$ units of $\rho \longrightarrow \Omega m$

$\vec{E} = \rho \vec{J}$

conductivity $\boxed{\sigma = 1/\rho}$ $\longrightarrow$ units of $(\Omega m)^{-1}$

$$\boxed{\vec{J} = 1/\rho\, \vec{E} = \sigma \vec{E}}$$

resistance of a conducting wire $\Rightarrow$ $\boxed{R = \rho L/A}$

$$\boxed{\begin{aligned} \rho - \rho_0 &= \rho_0 \alpha\,(T - T_0) \\ R - R_0 &= R_0 \alpha\,(T - T_0) \end{aligned}}$$

$\alpha \longrightarrow$ temp. coeff. of resistivity

units of α are $(K)^{-1}$ or $(C^\circ)^{-1}$

"Ohm's Law" $\longrightarrow$ $\boxed{V = iR \qquad i = V/R \qquad R = V/i}$

a conductor obeys Ohm's law if R is a constant independent of magnitude & polarity of voltage

$\boxed{P = iV}$ $\longrightarrow$ holds true for <u>any</u> electrical device

$$\boxed{\begin{aligned} P &= i^2 R \\ P &= V^2/R \end{aligned}}$$

$\longrightarrow$ only holds true for resistors

Chapter 27: Circuits

emf $\mathcal{E}$ → defined as $\boxed{\mathcal{E} = dW/dq}$

voltage across a battery with internal resistance r is given by:

$$\boxed{V = \mathcal{E} - ir}$$

for n resistors in series: $\boxed{R_{eq} = \sum_{i=1}^{n} R_i}$

for n resistors in parallel: $\boxed{\frac{1}{R_{eq}} = \sum_{i=1}^{n} \frac{1}{R_i}$}

* resistors in series have same i as R_{eq}

* resistors in parallel have same V as R_{eq}

<u>Kirchoff's junction rule</u> ⇒ $\boxed{i_{in} = i_{out}}$

Kirchoff's loop rule ⇒ $\boxed{\sum V = 0 \text{ around any closed loop}}$

↓

algebraic sum of the changes in potential around any closed loop is zero sign conventions for Kirchoff's loop rule:

<u>emf devices</u> → going through emf device from − to + terminal, the change in potential is $+\mathcal{E}$

↓ from + to − terminal, change in potential is $-\mathcal{E}$

<u>resistors</u> → going through resistor in same direction as current, the change in potential is $-iR$

↓ in opposite direction as current, the change in potential is $+iR$

* if you do not know the direction of the current, assume a direction → if i comes out negative, your assumed direction was wrong

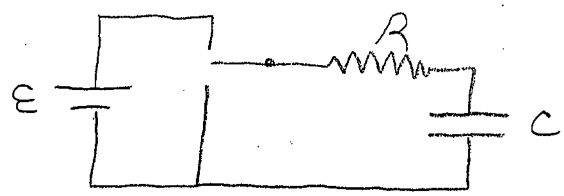
⇒ for an emf device $\boxed{P = i\mathcal{E}}$

* know how to calculate the potential difference between 2 points or the potential at one point given the potential at another point

ammeter → very small R (connected in series)

voltmeter → very large R (connected in parallel)

RC Circuits



charging a capacitor :

$$\boxed{q = q_0 (1 - e^{-t/\tau}) = C\mathcal{E}(1 - e^{-t/\tau})}$$

$$\boxed{V = q/C = \mathcal{E}(1 - e^{-t/\tau})}$$

$$\boxed{i = dq/dt = \mathcal{E}/R \; e^{-t/\tau}}$$

$$\boxed{\tau = RC}$$

capacitive time constant

discharging a capacitor :

$$\boxed{q = q_0 e^{-t/\tau}}$$

$$\boxed{i = dq/dt = -(q_0/RC)\, e^{-t/\tau}}$$

Chapter 28: Magnetic Fields

$\boxed{\vec{F}_B = q\vec{V} \times \vec{B}}$ → magnitude of $F_B = qvB\sin\theta$

↓

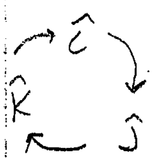
<u>direction given by RHR</u> ⇒ curl fingers of right hand from $\vec{V}$ into $\vec{B}$, thumb points in direction of $\vec{F}$ on a positive charge (opposite direction if charge is negative)

<u>Joe's RHR</u> ⇒

thumb → $\vec{V}$

fingers → $\vec{B}$

palm → $\vec{F}$



$\hat{i} \times \hat{j} = \hat{k}$ $\qquad$ $\hat{j} \times \hat{i} = -\hat{k}$

$\hat{j} \times \hat{k} = \hat{i}$ $\qquad$ $\hat{k} \times \hat{j} = -\hat{i}$

$\hat{k} \times \hat{i} = \hat{j}$ $\qquad$ $\hat{i} \times \hat{k} = -\hat{j}$

$$\vec{V} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ V_x & V_y & V_z \\ B_x & B_y & B_z \end{vmatrix} = \hat{i}\begin{vmatrix} V_y & V_z \\ B_y & B_z \end{vmatrix} - \hat{j}\begin{vmatrix} V_x & V_z \\ B_x & B_z \end{vmatrix} + \hat{k}\begin{vmatrix} V_x & V_y \\ B_x & B_y \end{vmatrix}$$

* $\vec{F}_B$ is always $\perp$ to both $\vec{V}$ and $\vec{B}$

↓

magnetic fields can not change the speed of a moving charged particle, only the direction of the particle

unit of $\vec{B}$ → tesla (T) $\quad \boxed{1\,T = 1\,N/Am}$

⇒ if both $\vec{E}$ & $\vec{B}$ fields are present : $\boxed{\vec{F} = q(\vec{E} + \vec{V} \times \vec{B})}$

$\Rightarrow$ for crossed $\vec{E}$ + $\vec{B}$ fields in opposition, the net force on a charged particle is zero if: $\boxed{V = E/B}$

Circulating Charged Particle

$\boxed{r = \frac{mv}{qB}}$ $\boxed{T = \frac{2\pi m}{qB}}$ $\boxed{f = \frac{qB}{2\pi m}}$

above equation apply if $\vec{V} \perp \vec{B}$

$\Rightarrow$ if $\vec{V}$ is not $\perp$ to $\vec{B}$, the particle moves in a helical path

radius of helix $\boxed{r = \frac{m V_{\perp}}{qB}}$ $V_{\perp} = V \sin\theta$

pitch $\boxed{p = V_{\parallel} T}$ $V_{\parallel} = V \cos\theta$

magnetic force on a current-carrying wire $\Rightarrow$ $\boxed{\vec{F} = i\vec{L} \times \vec{B}}$

magnitude of $F = iLB\sin\theta$

direction of $\vec{F}$ from RHR $\Rightarrow$ curl fingers of RH from $\vec{L}$ (which is in direction of conventional current) into $\vec{B}$, thumb points in direction of $\vec{F}$

⇒ the net force on a closed current-carrying loop of wire in a uniform $\vec{B}$-field is zero

↓ however, current loop may experience a torque

$$\boxed{\tau = N i A B \sin\theta}$$

magnetic dipole moment $\boxed{\mu = N i A}$

↓

direction of $\vec{\mu}$ ⇒ curl fingers of RH in direction of conventional current, thumb points in direction of $\vec{\mu}$

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

⇒ potential energy of a magnetic dipole in an external magnetic field is given by:

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

Chapter 29: Magnetic Fields Due to Currents

Biot-Savart law $\Rightarrow$ $\boxed{d\vec{B} = \frac{\mu_0}{4\pi} \frac{i\, d\vec{s} \times \vec{r}}{r^3}}$

magnitude $\boxed{dB = \frac{\mu_0}{4\pi} \frac{i\, ds \sin\theta}{r^2}}$

direction of $d\vec{B}$ is given by $d\vec{s} \times \vec{r}$

$\boxed{\vec{B} = \int d\vec{B}}$

$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{Tm/A} \approx 1.26 \times 10^{-6}\ \mathrm{Tm/A}$

long (infinite) straight wire $\Rightarrow$ $\boxed{B = \frac{\mu_0 i}{2\pi r}}$

semi-infinite straight wire $\Rightarrow$ $\boxed{B = \frac{\mu_0 i}{4\pi r}}$

center of circular arc of radius R and angle ϕ (in radians) $\Rightarrow$ $\boxed{B = \frac{\mu_0 i \phi}{4\pi R}}$

force between two parallel currents $\Rightarrow$ $\boxed{F = \frac{\mu_0 L i_1 i_2}{2\pi d}}$

* parallel currents attract, antiparallel currents repel

Ampere's law $\Rightarrow$ $$\boxed{\oint \vec{B}\cdot d\vec{s} = \mu_0 i_{encl}}$$

<u>RHR for Ampere's law</u> $\Rightarrow$ curl fingers of RH in direction of Amperian loop; currents in general direction of thumb are +, currents in opposite direction are −

inside long straight wire with uniform current density $\Rightarrow$ $$\boxed{B = \left(\frac{\mu_0 i}{2\pi R^2}\right) r}$$

ideal solenoid $\Rightarrow$ $$\boxed{B = \mu_0 i n}$$

n = # turns per unit length

B inside solenoid

$B = 0$ outside ideal solenoid

inside toroid $$\boxed{B = \frac{\mu_0 i N}{2\pi}\frac{1}{r}}$$

$B = 0$ outside toroid

<u>skip</u>

$$\boxed{\vec{B}(z) = \frac{\mu_0}{2\pi}\frac{\vec{\mu}}{z^3}}$$

$\rightarrow$ $\vec{B}$ a distance z above center of a current carrying coil

$$\boxed{\mu = N i A}$$