Midterm 2 Sheet

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9) Electric Current + Ohm's Law

$$R = \rho \frac{L}{A}$$ ρ = resistivity

$$\rho = \rho_0(1 + \alpha[T - 20°C])$$

α = temp coefficient

ρ_0 = resistivity @ 20°C

$$V = IR$$

Series

$R = R_1 + R_2 + \ldots$

$I = I_1 = I_2 = \ldots$

$V = V_1 + V_2 + \ldots$

Parallel

$$R = \left(\frac{1}{R_1} + \frac{1}{R_2} + \ldots\right)^{-1}$$

$I = I_1 + I_2 + \ldots$

$V = V_1 = V_2 = \ldots$

$$P = IV = \frac{V^2}{R} = I^2R$$

10) Kirchhoff's Rules

1. Junction

$I_0 = I_1 + I_2 + $

$$\frac{V_0}{R_{eq}} = \frac{V_0}{R_1} + \frac{V_0}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

2. Cons. of E

$$\sum_{Loop} V_n = 0$$

11) RC Circuits

$$V_c(t) = V_B\left[1 - e^{\frac{-t}{RC}}\right]$$

$$Q(t) = CV_B\left[1 - e^{\frac{-t}{RC}}\right]$$

$$I(t) = \frac{V_B}{R} e^{\frac{-t}{RC}}$$ $\frac{V_B}{R} = I_{max}$

Golden Rules

1. Capacitors act like wires when first connected to a battery.
2. Once fully charged, capacitors act like open circuits (a break in the wire). Voltage of capacitor equals voltage of the branch it's connected to.
3. If a battery is dead, sometimes there is a discharge path available to empty a capacitor of its stored charge (capacitor acts like a battery but V↓ and I↓)

12) Mag Fields + Forces

$$F_B = qv \times B = qvB\sin\theta$$

F_B: Thumb points in dir of mag field

v: fingers point in the dir of

B: Curl them in the dir of

RHR

for neg charge, it is in opp dir of thumb

Note: This can work for other cross product stuff!!!

$$F = \frac{mv^2}{r} = qvB = Eq \qquad qB = \frac{mv}{r}$$

$s = r\theta$ s = arc len, r = radius, θ = radians

$$w = 2\pi f = \frac{2\pi}{T} = \frac{v}{r}$$

$$\theta = \theta_0 + wt + \frac{1}{2}\alpha t^2$$

13) Mag Torque + PE

$$F_{wire} = IL \times B$$

use RHR as described in 12)
curl fingers w/ current

$$\tau_{em} = IA \times B = IAB\sin\theta = NIA \times B$$

Important
Linear forces cancel
twisting forces usually don't
Net result is τ on loop

$\mu \equiv NIA$ Mag dipole moment

$$\tau = \mu \times B$$

$$W = \int \mu B \sin\theta \, d\theta = -\mu B \cos\theta \Big|_{\theta_i}^{\theta_f}$$

$\Delta U_m = -W$ Define $U=0$ @ max τ

$$U_m = -\mu \cdot B$$

14) Biot-Savart Law

$B = \frac{\mu_0 I}{2\pi r}$ Thumb: I
Fingers: curl in dir of B

apply to $qv \times B$ and $IL \times B$

15) B-fields of wires + Ampere's Law

$$B = \frac{\mu_0 I}{2\pi r} = \frac{2\times 10^{-7} I}{r}$$

$$\oint B \cdot ds = B 2\pi r = \mu_0 I_{inside}$$

↳ $B = \frac{\mu_0 I}{2\pi r}$

$$\frac{I_{inside}}{I_{tot}} = \frac{\pi r^2}{\pi R^2}$$

16) Motional EMF

$F = qv \times B = Eq$ $E = vB$

$$V = EL = vBL$$

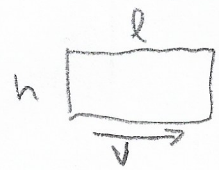
$$\mathcal{E} = lv \times B$$

17) Faraday's and Lenz' Laws

Faraday: $\mathcal{E}_{mf} = -\frac{\Delta \Phi_B}{\Delta t} = -\frac{d}{dt}\int B \cdot dA$

$$\Phi_B = BA\cos\theta = \int B \cdot dA$$

$$\Phi_E = \int E \cdot dA$$



$$\Phi = \int B \cdot dA = \int \frac{\mu_0 I}{2\pi x} h \, dx = \frac{\mu_0 I h}{2\pi}\int \frac{dx}{x}$$

$$\Phi_B = K\left(\frac{d+l}{d}\right), \quad K = \frac{\mu_0 I h}{2\pi}$$

$$\mathcal{E} = \frac{Klv}{x^2 + lx}$$

or

$\mathcal{E} = lv \times B$, $\mathcal{E}_{near} - \mathcal{E}_{far}$

Lenz:

1. Direction of field/flux b4 changes
2. Φ_B ↑ or ↓ based on change?
3. Make I flow in loop so no Φ_B change

If Φ_B ↑, I must flow to keep ↑ from happening

$$\mathcal{E} = -N\frac{\Delta \Phi}{\Delta t}$$