AP Physics C: E + M Notes

$F_e = \frac{kq_1q_2}{r^2}$

$E = \frac{F_e}{q} = \frac{kq}{r^2}$ (Point Charge)

- start @ $+q$ & end @ $-q$ (or ∞)
- never loops
- $\perp$ to surface

$\rho \equiv \frac{Q}{V}$; $\sigma \equiv \frac{Q}{A}$; $\lambda = \frac{Q}{L}$

$\Phi_E = \int E \cdot dA = EA\cos\theta$ (constant A, E, θ)

$\Phi_E = \oint E \cdot dA = \frac{q_{in}}{\epsilon_0}$

Gaussian Surface!

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emf vs. ΔV_t

(Ideal ΔV only w/ $I=0$) ($\Delta V_t = \mathcal{E} - Ir$)

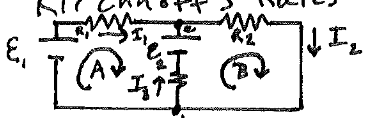
$R_{\parallel} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \dots\right)^{-1}$

(ΔV same, I add)

$R_{series} = R_1 + R_2 + \dots$

(I same & ΔV add)

Kirchhoff's Rules

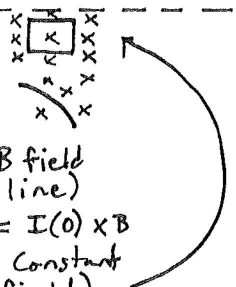


@ Junction $\Sigma I_{in} = \Sigma I_{out}$

Loop $\Delta V_{Loop} = 0$

$\tau = NI\vec{A} \times \vec{B}$

$= NIAB\sin\theta$



$dF_B = I d\vec{l} \times \vec{B}$

$\Rightarrow F_B = IL' \times \vec{B}$

(in constant B field $L' \Rightarrow$ straight line)

$F_B = I\oint d\vec{l} \times B = I(0) \times B$

$= 0$ (Loop in Constant B field)

$V_\perp$ to B field

Circular Motion

$\Sigma F_{in} = ma_c$ & $\omega = \frac{2\pi}{T}$

$dB = \frac{\mu_0}{4\pi}\frac{I d\vec{l} \times \vec{r}}{r^2}$

B field @ center of an Arc. & @ Axis of a Loop.

$\mathcal{E}_L = -L\frac{dI}{dt}$

$\Delta V = IR$

RL Circuit

$I(t) = \frac{\mathcal{E}}{R}(1 - e^{-\frac{Rt}{L}})$

$\frac{dI}{dt}(t) = \frac{\mathcal{E}}{L}(e^{-\frac{Rt}{L}})$

Putting energy into L

$I(0) = 0$ & $\frac{dI}{dt}(0) = \frac{\mathcal{E}}{L}$

$I(\infty) = \frac{\mathcal{E}}{R}$ & $\frac{dI}{dt}(\infty) = 0$

$U_{ele} = \frac{kq_1q_2}{r}$

$\Delta V = \frac{\Delta U_{ele}}{q} = \frac{kq}{r}$ (Point Charge)

$dV = \frac{k\,dq}{r}$ (Continuous Charge Distribution)

Scalar!

$\Delta V = -\int E \cdot dr = -E\Delta d$ (const E field)

1 electron Volt $= 1.6 \times 10^{-19}$ J

$C \equiv \frac{Q}{\Delta V} = \frac{\kappa\epsilon_0 A}{d}$

($\parallel$ Plate w/ dielectric)

$\Delta V_A = \mathcal{E}_1 - \Delta V_{R_1} - \mathcal{E}_2 + \Delta V_{R_3} = 0$

$= \mathcal{E}_1 - I_1R_1 - \mathcal{E}_2 + I_3R_3 = 0$

$\Delta V_B = 0 = \mathcal{E}_2 - \Delta V_{R_2} - \Delta V_{R_3}$

$0 = \mathcal{E}_2 - I_2R_2 - I_3R_3$

$\Sigma I_{in} = \Sigma I_{out}$ Junction a

$I_1 + I_3 = I_2$

RC Circuit

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

$I(t) = \frac{\mathcal{E}}{R}e^{-t/RC}$

charging

$t \approx 0 \Rightarrow I = I_{max}$ & $Q = 0$

$t \approx \infty \Rightarrow I \approx 0$ $Q \approx Q_{max}$

$B_s = \frac{\mu_0 NI}{l}$ (solenoid)

$\oint B \cdot dl = \mu_0 I_{in}$

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

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2 $\parallel$ Current Carrying Wires

$F_B = I_1 l \times B_2 = I_1 l B_2 \sin 90$

$= I_1 l \frac{\mu_0 I_2}{2\pi r}$

$F_B = \frac{I_1 I_2 \mu_0 l}{2\pi r}$

$\oint B \cdot dA = 0$

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

Removing Energy from L

$I(t) = \frac{\mathcal{E}}{R}e^{-\frac{Rt}{L}}$

$\frac{dI}{dt}(t) = -\frac{\mathcal{E}}{L}e^{-\frac{Rt}{L}}$

$I(0) = \frac{\mathcal{E}}{R}$ $\frac{dI}{dt}(0) = \frac{\mathcal{E}}{L}$

$I(\infty) = 0$ $\frac{dI}{dt}(\infty) = 0$

$U_L = \frac{1}{2}LI^2$

LC Circuit

$\frac{d^2Q}{dt^2} = -\frac{1}{LC}Q$

$\omega = \sqrt{\frac{1}{LC}} = \frac{2\pi}{T}$

$C_{series} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \dots\right)^{-1}$

(Q same & ΔV add)

$C_{\parallel} = C_1 + C_2 + \dots$

(ΔV same & Q add)

$U_c = \frac{Q^2}{2C} = \frac{1}{2}C\Delta V^2 = \frac{1}{2}Q\Delta V$

$I = \frac{dQ}{dt} = Nqv_dA$

$\Delta V = IR \Rightarrow R = \frac{\Delta V}{I}$

$R = \frac{\rho l}{A}$

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

Ammeter in series

(Low R: Same I Little change)

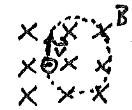
Voltmeter: in $\parallel$

(High R: Same ΔV Little change)

$F_B = q\vec{v} \times \vec{B}$ & RHR

$= qvB\sin\theta$

$= I\vec{L} \times \vec{B} = ILB\sin\theta$



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discharging

$q(t) = Q_i(e^{-t/RC})$

$I(t) = -I_i e^{-t/RC}$

$t \approx 0 \Rightarrow I = I_{max}$ & $Q = Q_{max}$

$t \approx \infty \Rightarrow I \approx 0$ $Q \approx 0$

$\tau = RC$ (63.2%)

$(1 - e^{-RC/RC}) = (1 - e^{-1}) = 0.632$

$\mathcal{E} = -N\frac{d\Phi_B}{dt} = -N\frac{d}{dt}(BA\cos\theta)$

Lenz' Law

B induced out I_{ind} is CCW

Motional Emf $\Delta V = vBl\sin\theta$

θ btwn $\vec{v}$ & $\vec{B}$

$\mathcal{E}_{gen} = \omega NBA\sin\omega t = \mathcal{E}_{back\ emf\ motor}$

$\mathcal{E}_L = -L\frac{dI}{dt} = -N\frac{d\Phi_B}{dt} \Rightarrow L = \frac{N\Phi_B}{I}$

$Q(t) = Q_{max}\cos(\omega t + \phi)$

$I = \frac{dQ}{dt}$

SHM $\Rightarrow$ Conservation of Energy.