1 Math

$e^{i\theta} = cos(\theta) + isin(\theta)$ Euler's Law

$\int \frac{1}{(R^2+x^2)^{3/2}} = \frac{x}{R^2(R^2+x^2)^{1/2}}$ A Common Integral

2 Constants

Electron/Proton Charge = -1.6E-19 [C]

Electron Mass = 9.11E-31 [kg]

Proton/Neutron Mass = 1.67E-27 [kg]

ε_o = 8.85 E-12 $[C^2/N \cdot m^2]$

k = 9E9 = 1/4$\pi\varepsilon_o$ $[N \cdot m^2/C^2]$

μ_o = 4πE-7 [T·m/A]

c = 3E-8 [m/s]

3 Electricity

$E = \frac{kq}{r^2}$ [N/C]

$F = \frac{k|q_1 q_2|}{r^2}$ [N]

$V = \frac{kq}{r}$ [V]

$W = -Vq$ [V·C]

4 Resistors

Use power

$\rho = \frac{E}{J} = \frac{RA}{L}$ [Ω·m] Resistivity

5 Capacitors

Store charge

$C = \kappa \varepsilon_o A/d$ Parallel Plates

$Q = VC$ Charge

$U_E = QV/C$ Potential Energy Stored

6 Inductors

Slow changes in current

Mutual inductance is the proportionality of EMF in coil 2 to change in current in coil 1, and vice versa

$M_{21} = M_{12} = N_2 \Phi_{B2}/I_1 = N_1 \Phi_{B1}/I_2$

$M = \mu_o A N_1 N_2/l$ Mutual Inductance

$\varepsilon_2 = -M \frac{\partial i_1}{\partial t}$ EMF from Mutual Inductance

$L = N\Phi_B/I$ Self Inductance

$V = -L\frac{\partial i}{\partial t}$ Voltage in inductor

$U_B = \frac{LI^2}{2C}$ Potential Energy Stored

7 Magnetism

$F = qv \times B$ [N] Force on charge

$F = Il \times B$ [N] Force on conductor

$\frac{F}{l} = \frac{\mu_o I_1 I_2}{2\pi d}$ [F/m] Force between parallel conductors

$\vec{B} = \frac{\mu_o q v \times \hat{r}}{4\pi r^2}$ [T]

$\partial\vec{B} = \frac{\mu_o I \partial\vec{l} \times \hat{r}}{4\pi r^2}$ [∂T]

$r = \frac{mv}{qB}$ [m] Circling Charge

$\tau = NBIAsin(\theta)$ [N·m] Spinning Rectangular Loop

$B = \frac{\mu_o I}{2\pi d}$ [T] Infinitely Long Wire

$B = \mu_o n I$ [T] Inside Solenoid, n=N/l

$B = \frac{\mu_o I a^2}{2(x^2+a^2)^{3/2}}$ [T] Axis of Circular Loop

$\mu = NIA$ [A·m^2],[N·m/T] Magnetic Moment

$\Phi_B = BAsin(\theta)$ [T·m^2] Flux in constant field

$\Phi_B = \iint B \cdot dA$ [T·m^2] Flux in varying field

$\varepsilon = -N\frac{-\partial\Phi_E}{\partial t}$ [V] Induced EMF

$\varepsilon = Blv$ [V] Motional EMF

8 Maxwell's Equations

$\oiint_S J\, dA = \frac{q_{enclosed}}{\varepsilon_o}$ Gauss's Law for Electricity

$\oiint_S B\, dA = 0$ Gauss's Law for Magnetism

$\oint E\, dl = \frac{-\partial\Phi_B}{\partial t}$ Faraday's Law

$\oint B\, dl = \mu_o(I_{enclosed} + \epsilon_o\frac{-\partial\Phi_E}{\partial t})$ Ampere's Law Modified

9 Transformers

Step up transformer increases output voltage

$V_2/V_1 = N_2/N_1$ Voltage proportional to loops

$V_1 I_1 = V_2 I_2$ Power is conserved

10 Circuits

$I_{RMS} = \frac{I_{max}}{\sqrt{2}}$

$I_{RAV} = \frac{2}{\pi} I_{max}$

$\tau = RC$ RC Circuit Time Constant

$\tau = L/R$ LR Circuit Time Constant

$I = I_o e^{\frac{-t}{\tau}}$ Current when Discharging

$I = I_o(1 - e^{\frac{-t}{\tau}})$ Current when Charging

11 Series Circuits

R_{eff}, L_{eff} are the sum of their sub-components

C_{eff}, Q_{eff} are the inverse of the sum of inversed sub-components

Resonance when voltage to resistor is max and capacitor/inductor impedance is zero

$V_s^2 = V_R^2 + (V_L - V_C)^2$

$I_s = I_R = I_L = I_C$

$Z^2 = R^2 + (X_L - X_C)^2$ Reactance Geometric Format

$\widetilde{Z} = R + (X_L - X_C)i$ Reactance Complex Format

$cos(\theta) = R/Z$

12 Parallel Circuits

Q_{eff}, C_{eff} are the sum of their sub-components

R_{eff}, L_{eff} are the inverse of the sum of inversed sub-components

Resonance when current to resistor is max and capacitor/inductor impedance is infinite

$I_s^2 = I_R^2 + (I_L - I_C)^2$

$V_s = V_R = V_L = V_C$

$\frac{1}{Z} = \sqrt{(\frac{1}{R})^2 + (\frac{1}{X_L} - \frac{1}{X_C})^2}$ Reactance Geometric Format

$\frac{1}{\widetilde{Z}} = \frac{1}{R} + (\frac{1}{X_L} - \frac{1}{X_C})i$ Reactance Complex Format

$Y = \frac{1}{Z}$ Admittance

$cos(\theta) = Z/R$ Angle between current and voltage

13 Both Circuits

Leading means current is ahead of voltage in phase diagram

$\omega = \frac{1}{\sqrt{LC}}$ Resonance Frequency when Net Reactance is 0

$X_L = \omega L$

$\widetilde{Z_L} = iX_L$ Inductor Reactance

$X_C = \frac{1}{\omega C}$

$\widetilde{Z_C} = -iX_C$ Capacitor Reactance

$P = \frac{1}{2} V_{max} I_{max} cos(\theta)$ Power

14 With Damping

$\omega\prime = \sqrt{\omega^2 - (R/2L)^2}$