122 Final Exam Equations, Tipler Chapters 21-30

Previous equations:

$k = \frac{1}{4\pi\varepsilon_0} = 8.99\times10^9\, N\bullet m^2/C^2$ $\varepsilon_0 = \frac{1}{4\pi k} = 8.85\times10^{-12}\, C^2/(N\bullet m^2)$ $e = 1.60\times10^{-19} C$

Charge density: $\rho = \frac{Q}{V}$ C/m^3 $\sigma = \frac{Q}{A}$ C/m$^2 = \rho\ell$ $\lambda = \frac{Q}{\ell}$ C/m $= \rho A$ where $V = A\ell$

E field: pt. chg. or symmetrical sphere: $E = \frac{kQ}{r^2}$ for $r > R_{sphere}$ Infinite line: $E = \frac{1}{2\pi\varepsilon_0}\frac{\lambda}{R}$

Potential: symmetrical sphere: $V = \frac{kQ}{r}$ for r > R$_{sphere}$ inf. line: $V = 2k\lambda \ln\frac{R_{ref}}{R}$

Def: $C = \frac{Q}{V}$ $U = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$ $u_e = \frac{1}{2}\varepsilon_0 E^2$ Dielectric: $C = \kappa C_0$

Par: $C_{eq} = C_1 + C_2 + C_3 + \ldots$ Ser: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$ $I = \frac{\Delta Q}{\Delta t}$ $R = \rho\frac{L}{A}$

$V = IR$ $P = IV$ Resistor: Par: $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ Ser: $R_{eq} = R_1 + R_2 + \ldots$

Dischg: $Q(t) = Q_0 e^{-t/\tau}$ Charg: $Q(t) = Q_f\left(1 - e^{-t/\tau}\right)$ either: $\tau = RC$ and $I(t) = I_0 e^{-t/\tau}$

Chapter 26:

$\vec{F} = q\vec{v}\times\vec{B}$ $\vec{F} = I\vec{L}\times\vec{B}$ $d\vec{F} = I\,d\vec{\ell}\times\vec{B}$ $qvB = mv^2/r$ $T = \frac{2\pi m}{qB}$

$v = \frac{E}{B}$ $\vec{\mu} = NIA\hat{n}$ $\vec{\tau} = \vec{\mu}\times\vec{B}$ $U = -\vec{\mu}\bullet\vec{B}$ $V_H = E_H w = v_d B w = \frac{I}{nte}B$

Chapter 27: $\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$ $\mu_0 = 4\pi\times10^{-7}$ T•m/A Biot-Savart: $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\ell\times\hat{r}}{r^2}$

on axis of loop: $B_z = \frac{\mu_0}{4\pi}\frac{2\pi R^2 I}{\left(z^2 + R^2\right)^{3/2}}$ near center long solenoid: $B = \mu_0 nI$

straight wire segment: $B = \frac{\mu_0}{4\pi}\frac{I}{R}(\sin\theta_2 - \sin\theta_1)$ inside tight toroid: $B = \frac{\mu_0}{2\pi}\frac{NI}{r}$

Gauss for magnetism: $\phi_{m\,net} = \oint_S \vec{B}\bullet\hat{n}\,dA = 0$ Ampere: $\oint_C \vec{B}\bullet d\vec{\ell} = \mu_0 I_{enc}$

Chapter 28: magnetic flux: $\phi_m = \int_S \vec{B}\bullet\hat{n}\,dA$ flat area multiple turns: $\phi_m = NBA\cos\theta$

Faraday: $\varepsilon = -\frac{d\phi_m}{dt}$ $\varepsilon = \oint_C \vec{E}\bullet d\vec{\ell}$ rod moves $\perp$ B: $|\varepsilon| = vB\ell$ self-induced: $\varepsilon = -L\frac{dI}{dt}$

Chapter 28 continued: Energy: $U = \frac{1}{2}LI^2$ energy density: $u_m = \frac{B^2}{2\mu_0}$

Self inductance: $L = \frac{\phi_m}{I}$ solenoid: $L = \mu_0 n^2 A\ell$ Mutual: $M = \frac{\phi_{m21}}{I_1} = \frac{\phi_{m12}}{I_2}$

LR circuits: Build up: $I(t) = I_f\left(1 - e^{-t/\tau}\right)$ Die out: $I(t) = I_0 e^{-t/\tau}$ Time constant: $\tau = \frac{L}{R}$

Chapter 29: Generator: $\mathcal{E} = \mathcal{E}_{peak}\cos(\omega t + \delta)$ current: $I_{rms} = \frac{1}{\sqrt{2}}I_{peak} = \sqrt{(I^2)_{av}}$

Resistor: $I_{rms} = \frac{V_{R\,rms}}{R}$ Inductor: $I_{rms} = \frac{V_{L\,rms}}{\omega L} = \frac{V_{L\,rms}}{X_L}$ Capacitor: $I_{rms} = \frac{V_{C\,rms}}{1/\omega C} = \frac{V_{C\,rms}}{X_C}$

Reactance: $X_L = \omega L$ and $X_C = \frac{1}{\omega C}$ Impedance: $Z = \sqrt{R^2 + (X_L - X_C)^2}$

Average power: resistor: $P_{av} = V_{R\,rms}I_{rms} = I_{rms}^2 R$ inductor, capacitor: $P_{av} = 0$

Transformers: $V_2 = \frac{N_2}{N_1}V_1$ and $V_{1rms}I_{1rms} = V_{2rms}I_{2rms}$

Free LC: $\omega_0 = \frac{1}{\sqrt{LC}}$ Free RLC: $\omega_d = \sqrt{\frac{1}{LC} - \alpha^2}$ where $\alpha = \frac{R}{2L}$.

Driven RLC: generator: $V_{app} = V_{peak}\cos\omega t$ current: $I = \frac{V_{peak}}{Z}\cos(\omega t - \delta)$

Phase angle: $\tan\delta = \frac{X_L - X_C}{R}$ Average power: $P_{av} = I_{rms}^2 R = V_{app\,rms}I_{rms}\cos\delta$

Resonance: $X_L = X_C$, $Z = R$, $\delta = 0$, $\omega = \omega_0$

Chapter 30: $I_d = \varepsilon_0 \frac{d\phi_e}{dt} = \varepsilon_0 \frac{d}{dt}\int_S \vec{E}\cdot d\vec{A}$ Faraday's law: $\oint_C \vec{E}\cdot d\vec{\ell} = -\frac{d}{dt}\int_S \vec{B}\cdot d\vec{A}$

Ampere's Law (Modified): $\oint_C \vec{B}\cdot d\vec{\ell} = \mu_0(I_{enc} + I_d) = \mu_0 I_{enc} + \mu_0\varepsilon_0 \frac{d}{dt}\int_S \vec{E}\cdot d\vec{A}$

Gauss electric: $\oint_S \vec{E}\cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$ Gauss magnetic: $\oint_S \vec{B}\cdot d\vec{A} = 0$

EM waves: $E = cB$ energy transport: $\vec{S} = \frac{\vec{E}\times\vec{B}}{\mu_0}$ speed: $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3.0\times10^8$ m/s

$$\vec{F} = q\vec{v}\times\vec{B} \qquad \vec{F} = I\vec{L}\times\vec{B} \qquad \tau = \vec{r}\times\vec{F} \qquad \tau = \vec{\mu}\times\vec{B}$$

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

or