

Equations for Physics 122 Midterm 1:

Constants:

$$\begin{aligned} k &= \frac{1}{4\pi\epsilon_0}, \\ k &= 8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}, \\ \epsilon_0 &= \frac{1}{4\pi k}, \\ \epsilon_0 &= 8.85 \times 10^{-12} \frac{\text{C}^2}{\text{N}\cdot\text{m}^2}, \\ e &= 1.60 \times 10^{-19} \text{ C}, \\ m_e &= 9.1 \times 10^{-31} \text{ kg} \end{aligned}$$

Charge densities & dipole moment:

$$\begin{aligned} \sigma &= \frac{Q}{A}, \\ \lambda &= \frac{Q}{L}, \\ \rho &= \frac{Q}{v}, \\ \vec{p} &= q\vec{L} \end{aligned}$$

Force and torque:

$$\begin{aligned} \vec{F} &= q\vec{E}, \\ \vec{r} &= \vec{p} \times \vec{E}, \\ \vec{F} &= \vec{p} \cdot \vec{\nabla} \vec{E}, \end{aligned}$$

Electric Field:

$$\begin{aligned} \vec{E}(\vec{r}) &= -\vec{\nabla}V(\vec{r}), \\ \vec{E}(\vec{r}) &= \frac{q\hat{r}}{4\pi\epsilon_0 r^2}, \\ \vec{E}(\vec{r}) &= \sum_i \frac{q_i \hat{r}_i}{4\pi\epsilon_0 r_i^2}, \\ \vec{E}(\vec{r}) &= \int dq_{\vec{r}'} \frac{\vec{r} - \vec{r}'}{4\pi\epsilon_0 |\vec{r} - \vec{r}'|^3}, \\ \vec{E}(\vec{r}) &= \frac{\lambda \hat{r}}{2\pi\epsilon_0 r}, \\ \vec{E}(\vec{r}) &= \frac{\sigma \hat{n}}{2\epsilon_0}, \\ \vec{E}(\vec{r}) &= \frac{\sigma \hat{n}}{\epsilon_0}, \\ \vec{E}(\vec{r}) &= \frac{1}{4\pi\epsilon_0 r^3} [3(\hat{r} \cdot \vec{p})\hat{r} - \vec{p}], \end{aligned}$$

Electric flux and Gauss Law:

$$\begin{aligned} \Phi_M &\equiv \oint_M d^2A \hat{n} \cdot \vec{E}(\vec{r}), \\ &= \frac{Q_{\text{ins}}}{\epsilon_0}, \\ \vec{\nabla} \cdot \vec{E} &= \frac{\rho}{\epsilon_0}, \end{aligned}$$

Electric Potential:

$$\begin{aligned} V(\vec{r}) &= - \int_{\infty}^{\vec{r}} d\vec{\ell}' \cdot \vec{E}(\vec{r}'), \\ V(\vec{r}) &= \frac{q}{4\pi\epsilon_0 r}, \\ V(\vec{r}) &= \sum_i \frac{q_i}{4\pi\epsilon_0 r_i}, \\ V(\vec{r}) &= \int dq_{\vec{r}'} \frac{1}{4\pi\epsilon_0 |\vec{r} - \vec{r}'|}, \\ V(\vec{r}) &= -\frac{\lambda}{2\pi\epsilon_0} \log r, \\ V(\vec{r}) &= \frac{\vec{p} \cdot \hat{r}}{4\pi\epsilon_0 r^2} \end{aligned}$$

Energy and work:

$$\begin{aligned} dU &= dQ V, \\ dW &= d\vec{\ell} \cdot \vec{F}, \\ W &= -\Delta U, \\ U &= \frac{1}{2} \sum_{i \neq j} \frac{q_i q_j}{4\pi\epsilon_0 r_{ij}}, \\ U &= -\vec{p} \cdot \vec{E}, \\ K &= \frac{1}{2}mv^2, \end{aligned}$$

Capacitance:

$$\begin{aligned} Q &= CV, \\ C &= \frac{\epsilon_0 A}{\ell}, \\ C &= \frac{4\pi\epsilon_0 R_1 R_2}{R_2 - R_1}, \\ C &= \frac{2\pi\epsilon_0 L}{\log \frac{R_2}{R_1}}, \\ U &= \frac{1}{2}CV^2 = \frac{1}{2}QV = \frac{1}{2C}Q^2, \\ C_{\text{eq}} &= C_1 + C_2, \\ C_{\text{eq}}^{-1} &= C_1^{-1} + C_2^{-1}, \end{aligned}$$

Energy density:

$$u = \frac{1}{2}\epsilon_0 E^2,$$

Differential geometry:

$$\begin{aligned} \vec{\nabla} &\equiv \hat{x} \frac{\partial}{\partial x} + \hat{y} \frac{\partial}{\partial y} + \hat{z} \frac{\partial}{\partial z}, \\ &\equiv \hat{r} \frac{\partial}{\partial r} + \hat{\theta} \frac{1}{r} \frac{\partial}{\partial \theta} + \hat{\phi} \frac{1}{r \sin \theta} \frac{\partial}{\partial \phi}, \\ &\equiv \hat{r} \frac{\partial}{\partial r} + \hat{\phi} \frac{1}{r} \frac{\partial}{\partial \theta} + \hat{z} \frac{\partial}{\partial z}, \end{aligned}$$

$$\begin{aligned} d\vec{\ell} &= \hat{x} dx + \hat{y} dy + \hat{z} dz, \\ d\vec{\ell} &= \hat{r} dr + \hat{\theta} r d\theta + \hat{\phi} r \sin \theta d\phi, \\ d\vec{\ell} &= \hat{r} dr + \hat{\phi} r d\phi + \hat{z} dz, \\ d^2A &= r^2 \sin \theta d\theta d\phi, \\ d^2A &= r d\theta dz, \\ d^3v &= r^2 \sin \theta dr d\theta d\phi, \\ d^3v &= r dr d\theta dz \end{aligned}$$

Geometry:

$$\begin{aligned} A &= 4\pi R^2, \\ v &= \frac{4}{3}\pi R^3, \\ A &= 2\pi RL, \\ v &= \pi R^2 L \end{aligned}$$

Quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Equations for Physics 122 Midterm 2+:

Constants:

$$\begin{aligned}\mu_0 &= 4\pi \times 10^{-7} \text{ N/A}^2, \\ &\approx 1.26 \times 10^{-6} \text{ N/A}^2, \\ c &\approx 3 \times 10^8 \text{ m/s},\end{aligned}$$

Force and torque:

$$\begin{aligned}\vec{F} &= q(\vec{E} + \vec{v} \times \vec{B}), \\ \vec{F} &= IL \vec{B}, \\ \vec{r} &= \vec{\mu} \times \vec{B},\end{aligned}$$

Circular motion:

$$R_o = \frac{mv}{qB}$$

Current and resistance:

$$\begin{aligned}I &= \frac{d}{dt} Q, \\ I &= \int d^2A \hat{n} \cdot \vec{j}, \\ \vec{E} &= \rho \vec{j}, \\ V &= IR, \\ P &= I^2 R = IV = V^2/R, \\ R &= \rho L/A, \\ R_{||}^{-1} &= \sum_i R_i^{-1}, \\ R_{\text{series}} &= \sum_i R_i,\end{aligned}$$

Kirchhoff Laws:

$$\begin{aligned}\sum_{\text{in}} I_i &= \sum_{\text{out}} I_i, \\ 0 &= \sum_{\text{loop}} \Delta V_i,\end{aligned}$$

$$\Delta V = IR,$$

$$\Delta V = L \frac{d}{dt} I,$$

$$\Delta V = Q/C,$$

RC Circuits:

$$\begin{aligned}\tau &= RC, \\ Q &= Q_0 e^{-t/\tau}, \\ Q &= Q_\infty (1 - e^{-t/\tau}),\end{aligned}$$

RL Circuits:

$$\begin{aligned}\tau &= L/R, \\ I &= I_0 e^{-t/\tau}, \\ I &= I_\infty (1 - e^{-t/\tau}),\end{aligned}$$

Magnetic moment:

$$\begin{aligned}\vec{\mu} &= -\frac{1}{2} \oint_{\partial M} d\ell \times \vec{r}, \\ &= IAN \hat{n}, \\ U &= -\vec{\mu} \cdot \vec{B},\end{aligned}$$

Faraday law & emf:

$$\begin{aligned}\mathcal{E} &= \int d\ell \cdot (\vec{E} + \vec{v} \times \vec{B}), \\ \mathcal{E} &= -\frac{d}{dt} \Phi_B, \\ \Phi_B &= \int d^2A \hat{n} \cdot \vec{B},\end{aligned}$$

Biot-Savart & Ampere:

$$\begin{aligned}d\vec{B} &= \frac{\mu_0 I d\ell \times \hat{r}}{4\pi r^2}, \\ \oint d\ell \cdot \vec{B} &= \mu_0 I_{\text{ins}},\end{aligned}$$

B fields:

$$\begin{aligned}B &= \frac{1}{2} \mu_0 n I, \\ B &= \mu_0 n I, \\ \vec{B} &= \frac{\mu_0 I}{2\pi R} \hat{\theta},\end{aligned}$$

Energy and energy density:

$$\begin{aligned}U &= \frac{1}{2} LI^2, \\ u_B &= \frac{1}{2\mu_0} B^2,\end{aligned}$$

Maxwell Eqns:

$$\begin{aligned}\oint d^2A \hat{n} \cdot \vec{E} &= Q/\epsilon_0, \\ \oint d^2A \hat{n} \cdot \vec{B} &= 0, \\ \oint_{\partial M} d\ell \cdot \vec{B} &= \mu_0 \left[I + \epsilon_0 \int_M d^2A \hat{n} \cdot \frac{\partial}{\partial t} \vec{E} \right], \\ \oint_{\partial M} d\ell \cdot \vec{E} &= - \int_M d^2A \hat{n} \cdot \frac{\partial}{\partial t} \vec{B},\end{aligned}$$

Induction:

$$\begin{aligned}L &= \Phi_B/I, \\ L &= \mu_0 n^2 A \ell, \\ \mathcal{E} &= -L \frac{d}{dt} I,\end{aligned}$$

Geometry in cylindrical coordinates:

$$\begin{aligned}\hat{r} &= \cos \theta \hat{x} + \sin \theta \hat{y}, \\ \hat{\theta} &= -\sin \theta \hat{x} + \cos \theta \hat{y},\end{aligned}$$

RLC circuits:

$$\begin{aligned}V(t) &= V_0 \cos(\omega t + \phi) e^{-\beta t}, \\ \beta &= \frac{R}{2L}, \\ \omega^2 &= \omega_0^2 - \beta^2, \\ \omega_0 &= \frac{1}{\sqrt{LC}},\end{aligned}$$

Driven RLC circuits:

$$\begin{aligned}\vec{E}(t) &= \mathcal{E}_m \cos \omega t \hat{x} + \mathcal{E}_m \sin \omega t \hat{y}, \\ \vec{I}(t) &= I_m \cos(\omega t - \phi) \hat{x} + I_m \sin(\omega t - \phi) \hat{y}, \\ Z &= \sqrt{R^2 + (X_L - X_C)^2}, \\ X_L &= \omega L, \\ X_C &= 1/\omega C, \\ \tan \phi &= \frac{X_L - X_C}{R}, \\ V_m &= Z I_m,\end{aligned}$$

Transformers:

$$\begin{aligned}V_s/N_s &= V_p/N_p, \\ I_s N_s &= I_p N_p,\end{aligned}$$

EM Waves:

$$\begin{aligned}ck &= \omega, \\ k &= \frac{2\pi}{\lambda}, \\ \omega &= 2\pi\nu, \\ \mu_0 \epsilon_0 &= c^{-2}, \\ \nabla^2 \vec{E} &= \mu_0 \epsilon_0 \partial_t^2 \vec{E}, \\ \vec{E} &= \vec{E}_0 \cos(\vec{k} \cdot \vec{r} - \omega t), \\ \vec{B} &= \vec{B}_0 \cos(\vec{k} \cdot \vec{r} - \omega t), \\ \vec{B}_0 &= \frac{1}{c} \frac{\vec{k}}{k} \times \vec{E}_0, \\ \vec{k} \cdot \vec{E}_0 &= 0,\end{aligned}$$