

Equations for Physics 122 Midterm 1:

Constants:

$$k = \frac{1}{4\pi\epsilon_0},$$

$$k = 8.99 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2},$$

$$\epsilon_0 = \frac{1}{4\pi k},$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{\text{C}^2}{\text{N}\cdot\text{m}^2},$$

$$e = 1.60 \times 10^{-19} \text{ C},$$

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

Charge densities & dipole moment:

$$\sigma = \frac{Q}{A},$$

$$\lambda = \frac{Q}{L},$$

$$\rho = \frac{Q}{v},$$

$$\vec{p} = q\vec{L}$$

Force and torque:

$$\vec{F} = q\vec{E},$$

$$\vec{\tau} = \vec{p} \times \vec{E},$$

$$\vec{F} = \vec{p} \cdot \nabla \vec{E},$$

Electric Field:

$$\vec{E}(\vec{r}) = -\nabla V(\vec{r}),$$

$$\vec{E}(\vec{r}) = \frac{q\hat{r}}{4\pi\epsilon_0 r^2},$$

$$\vec{E}(\vec{r}) = \sum_i \frac{q_i \hat{r}_i}{4\pi\epsilon_0 r_i^2},$$

$$\vec{E}(\vec{r}) = \int dq_{\vec{r}'} \frac{\vec{r} - \vec{r}'}{4\pi\epsilon_0 |\vec{r} - \vec{r}'|^3},$$

$$\vec{E}(\vec{r}) = \frac{\lambda \hat{r}}{2\pi\epsilon_0 r},$$

$$\vec{E}(\vec{r}) = \frac{\sigma \hat{n}}{2\epsilon_0},$$

$$\vec{E}(\vec{r}) = \frac{\sigma \hat{n}}{\epsilon_0},$$

$$\vec{E}(\vec{r}) = \frac{1}{4\pi\epsilon_0 r^3} [3(\hat{r} \cdot \vec{p})\hat{r} - \vec{p}],$$

Electric flux and Gauss Law:

$$\Phi_{\mathcal{M}} \equiv \oint_{\mathcal{M}} d^2A \hat{n} \cdot \vec{E}(\vec{r}),$$

$$= \frac{Q_{\text{ins}}}{\epsilon_0},$$

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0},$$

Electric Potential:

$$V(\vec{r}) = - \int_{\infty}^{\vec{r}} d\vec{\ell}' \cdot \vec{E}(\vec{r}'),$$

$$V(\vec{r}) = \frac{q}{4\pi\epsilon_0 r},$$

$$V(\vec{r}) = \sum_i \frac{q_i}{4\pi\epsilon_0 r_i},$$

$$V(\vec{r}) = \int dq_{\vec{r}'} \frac{1}{4\pi\epsilon_0 |\vec{r} - \vec{r}'|},$$

$$V(\vec{r}) = -\frac{\lambda}{2\pi\epsilon_0} \log r,$$

$$V(\vec{r}) = \frac{\vec{p} \cdot \hat{r}}{4\pi\epsilon_0 r^2}$$

Energy and work:

$$dU = dQV,$$

$$dW = d\vec{\ell} \cdot \vec{F},$$

$$W = -\Delta U,$$

$$U = \frac{1}{2} \sum_{i \neq j} \frac{q_i q_j}{4\pi\epsilon_0 r_{ij}},$$

$$U = -\vec{p} \cdot \vec{E},$$

$$K = \frac{1}{2} m v^2,$$

Capacitance:

$$Q = CV,$$

$$C = \frac{\epsilon_0 A}{\ell},$$

$$C = \frac{4\pi\epsilon_0 R_1 R_2}{R_2 - R_1},$$

$$C = \frac{2\pi\epsilon_0 L}{\log \frac{R_2}{R_1}},$$

$$U = \frac{1}{2} C V^2 = \frac{1}{2} Q V = \frac{1}{2C} Q^2,$$

$$C_{\text{eq}} = C_1 + C_2,$$

$$C_{\text{eq}}^{-1} = C_1^{-1} + C_2^{-1},$$

Energy density:

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

Differential geometry:

$$\vec{\nabla} \equiv \hat{x} \frac{\partial}{\partial x} + \hat{y} \frac{\partial}{\partial y} + \hat{z} \frac{\partial}{\partial z},$$

$$\equiv \hat{r} \frac{\partial}{\partial r} + \hat{\theta} \frac{1}{r} \frac{\partial}{\partial \theta} + \hat{\phi} \frac{1}{r \sin \theta} \frac{\partial}{\partial \phi},$$

$$\equiv \hat{r} \frac{\partial}{\partial r} + \hat{\phi} \frac{1}{r} \frac{\partial}{\partial \phi} + \hat{z} \frac{\partial}{\partial z},$$

$$d\vec{\ell} = \hat{x} dx + \hat{y} dy + \hat{z} dz,$$

$$d\vec{\ell} = \hat{r} dr + \hat{\theta} r d\theta + \hat{\phi} r \sin \theta d\phi,$$

$$d\vec{\ell} = \hat{r} dr + \hat{\phi} r d\phi + \hat{z} dz,$$

$$d^2A = r^2 \sin \theta d\theta d\phi,$$

$$d^2A = r d\theta dz,$$

$$d^3v = r^2 \sin \theta dr d\theta d\phi,$$

$$d^3v = r dr d\theta dz$$

Geometry:

$$A = 4\pi R^2,$$

$$v = \frac{4}{3}\pi R^3,$$

$$A = 2\pi RL,$$

$$v = \pi R^2 L$$

Quadratic formula:

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