

FORMULA SHEET

$$dS = dx dy$$

$$dV = dx dy dz$$

$$dS = \rho d\phi dz$$

$$dV = \rho d\rho d\phi dz$$

$$dS = r^2 \sin\theta d\theta d\phi$$

$$dV = r^2 \sin\theta dr d\theta d\phi$$

$$d\underline{r} = \underline{\hat{z}} dz + \underline{\hat{\rho}} d\rho + \underline{\hat{\phi}} \rho d\phi$$

$$d\underline{r} = \underline{\hat{r}} dr + \underline{\hat{\phi}} r \sin\theta d\phi + \underline{\hat{\theta}} r d\theta$$

$$\nabla \cdot \underline{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$$

$$\nabla \cdot \underline{D} = \frac{1}{\rho} \frac{\partial}{\partial \rho} (\rho D_\rho) + \frac{1}{\rho} \frac{\partial D_\phi}{\partial \phi} + \frac{\partial D_z}{\partial z}$$

$$\nabla \cdot \underline{D} = \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 D_r) + \frac{1}{r \sin\theta} \frac{\partial}{\partial \theta} (D_\theta \sin\theta) + \frac{1}{r \sin\theta} \frac{\partial D_\phi}{\partial \phi}$$

$$\nabla \times \underline{V} = \underline{\hat{x}} \left(\frac{\partial V_z}{\partial y} - \frac{\partial V_y}{\partial z} \right) - \underline{\hat{y}} \left(\frac{\partial V_z}{\partial x} - \frac{\partial V_x}{\partial z} \right) + \underline{\hat{z}} \left(\frac{\partial V_y}{\partial x} - \frac{\partial V_x}{\partial y} \right)$$

$$\nabla \times \underline{V} = \underline{\hat{\rho}} \left(\frac{1}{\rho} \frac{\partial V_z}{\partial \phi} - \frac{\partial V_\phi}{\partial z} \right) + \underline{\hat{\phi}} \left(\frac{\partial V_\rho}{\partial z} - \frac{\partial V_z}{\partial \rho} \right) + \underline{\hat{z}} \frac{1}{\rho} \left(\frac{\partial (\rho V_\phi)}{\partial \rho} - \frac{\partial V_\rho}{\partial \phi} \right)$$

$$\nabla \times \underline{V} = \underline{\hat{r}} \frac{1}{r \sin\theta} \left[\frac{\partial (V_\phi \sin\theta)}{\partial \theta} - \frac{\partial V_\theta}{\partial \phi} \right] + \underline{\hat{\theta}} \frac{1}{r} \left[\frac{1}{\sin\theta} \frac{\partial V_r}{\partial \phi} - \frac{\partial (r V_\phi)}{\partial r} \right] + \underline{\hat{\phi}} \frac{1}{r} \left[\frac{\partial (r V_\theta)}{\partial r} - \frac{\partial V_r}{\partial \theta} \right]$$

$$\nabla\Phi \equiv \underline{\hat{x}} \frac{\partial\Phi}{\partial x} + \underline{\hat{y}} \frac{\partial\Phi}{\partial y} + \underline{\hat{z}} \frac{\partial\Phi}{\partial z}$$

$$\nabla\Phi = \underline{\hat{\rho}} \frac{\partial\Phi}{\partial\rho} + \underline{\hat{\phi}} \frac{1}{\rho} \frac{\partial\Phi}{\partial\phi} + \underline{\hat{z}} \frac{\partial\Phi}{\partial z}$$

$$\nabla\Phi = \underline{\hat{r}} \frac{\partial\Phi}{\partial r} + \underline{\hat{\theta}} \frac{1}{r} \frac{\partial\Phi}{\partial\theta} + \underline{\hat{\phi}} \frac{1}{r \sin\theta} \frac{\partial\Phi}{\partial\phi}$$

$$\nabla^2\Phi = \left(\frac{\partial^2\Phi}{\partial x^2} + \frac{\partial^2\Phi}{\partial y^2} + \frac{\partial^2\Phi}{\partial z^2} \right)$$

$$\nabla^2\Phi = \frac{1}{\rho} \frac{\partial}{\partial\rho} \left(\rho \frac{\partial\Phi}{\partial\rho} \right) + \frac{1}{\rho^2} \frac{\partial^2\Phi}{\partial\phi^2} + \frac{\partial^2\Phi}{\partial z^2}$$

$$\nabla^2\Phi = \frac{1}{r^2} \frac{\partial}{\partial r} \left(r^2 \frac{\partial\Phi}{\partial r} \right) + \frac{1}{r^2 \sin\theta} \frac{\partial}{\partial\theta} \left(\sin\theta \frac{\partial\Phi}{\partial\theta} \right) + \frac{1}{r^2 \sin^2\theta} \frac{\partial^2\Phi}{\partial\phi^2}$$

$$\int_V \nabla \cdot \underline{V} dV = \oint_S \underline{V} \cdot \underline{\hat{n}} dS$$

$$\int_S (\nabla \times \underline{V}) \cdot \underline{\hat{n}} dS = \oint_C \underline{V} \cdot \underline{dr}$$

$$\nabla \times \underline{E} = -\frac{\partial \underline{B}}{\partial t} \qquad \oint_C \underline{E} \cdot \underline{dr} = \int_S \left(-\frac{\partial \underline{B}}{\partial t} \right) \cdot \underline{\hat{n}} dS$$

$$\nabla \times \underline{H} = \underline{J} + \frac{\partial \underline{D}}{\partial t} \qquad \oint_C \underline{H} \cdot \underline{dr} = i_{\text{encl}} + \int_S \left(-\frac{\partial \underline{D}}{\partial t} \right) \cdot \underline{\hat{n}} dS$$

$$\nabla \cdot \underline{D} = \rho_v \qquad \oint_S \underline{D} \cdot \underline{\hat{n}} dS = Q_{\text{encl}}$$

$$\nabla \cdot \underline{B} = 0 \qquad \oint_S \underline{B} \cdot \underline{\hat{n}} dS = 0$$

$$i = \frac{dq}{dt}$$

$$i = \int_S \underline{J} \cdot \underline{\hat{n}} \, dS$$

$$\underline{J} = \rho_v \underline{v}$$

$$\underline{J} = \sigma \underline{E}$$

$$\underline{F} = q \underline{E}$$

$$V_{AB} = \int_A^B \underline{E} \cdot d\underline{r}$$

$$\text{PE}(\underline{r}) = q \Phi(\underline{r}) + C$$

$$\underline{E} = \int_V \frac{\rho_v}{4\pi\epsilon_0 R^2} \underline{\hat{R}} \, dV'$$

$$\underline{E} = \int_S \frac{\rho_s}{4\pi\epsilon_0 R^2} \underline{\hat{R}} \, dS'$$

$$\underline{E} = \int_V \frac{\rho_l}{4\pi\epsilon_0 R^2} \underline{\hat{R}} \, dl'$$

$$\underline{R} = \underline{r} - \underline{r}' = \underline{\hat{x}}(x - x') + \underline{\hat{y}}(y - y') + \underline{\hat{z}}(z - z')$$

$$R = |\underline{R}|$$

$$\underline{\hat{R}} = \frac{\underline{R}}{R}$$

$$\oint_S \underline{D} \cdot \underline{\hat{n}} \, dS = Q_{\text{encl}}$$

For PEC:

$$\underline{E} = \underline{0} \text{ (inside)}$$

$$\Phi = \text{constant (inside and on surface)}$$

$$\underline{E} = \underline{0} \text{ (inside)}$$

$$\rho_v = 0 \text{ (inside)}$$

$$\psi \equiv \int_S \underline{D} \cdot \underline{\hat{n}} \, dS$$

$$\psi_l \equiv \int_C \underline{D} \cdot \underline{\hat{n}} \, dl$$

$$\psi \propto N_S$$

$$\psi_l \propto N_C$$

$$\Phi(\underline{r}) = \Phi(\underline{R}) - \int_{\underline{R}}^{\underline{r}} \underline{E} \cdot d\underline{r}$$

$$\text{PE}(\underline{r}) = q\Phi(\underline{r}) + C$$

$$\Phi = \int_V \frac{\rho_v}{4\pi\epsilon_0 R} dV' \quad (\Phi(\infty) = 0)$$

$$\Phi = \int_S \frac{\rho_s}{4\pi\epsilon_0 R} dS' \quad (\Phi(\infty) = 0)$$

$$\Phi = \int_C \frac{\rho_l}{4\pi\epsilon_0 R} dl' \quad (\Phi(\infty) = 0)$$

$$\underline{E} = -\nabla\Phi$$

$$\nabla^2 \Phi = -\frac{\rho_v}{\epsilon}$$

$$\nabla^2 \Phi = 0 \quad (\rho_v = 0)$$

$$\text{Faraday's law: } \oint_C \underline{E} \cdot d\underline{r} = -\frac{d\psi}{dt} \quad (S \text{ is stationary})$$

$$\psi = \int_S \underline{B} \cdot \underline{\hat{n}} dS \quad (\underline{\hat{n}} \text{ from right - hand rule})$$

$$v(t) = \frac{d\psi_z}{dt}$$

$$\psi_z \equiv \int_S B_z dS$$

$$\underline{D} \equiv \epsilon_0 \underline{E} + \underline{P}$$

$$\underline{P} = \epsilon_0 \chi_e \underline{E}$$

$$\epsilon_r \equiv 1 + \chi_e$$

$$\epsilon = \epsilon_0 \epsilon_r$$

$$\underline{D} = \epsilon \underline{E}$$

$$\underline{D} \cdot \underline{\hat{n}} = \rho_s$$

$$\underline{\hat{n}} \cdot (\underline{D}_1 - \underline{D}_2) = \rho_s$$

$$\underline{E}_{t1} = \underline{E}_{t2}$$

$$\Phi = \frac{\rho_{l0}}{2\pi\epsilon_0} \ln\left(\frac{b}{\rho}\right) \quad (\text{line charge})$$

$$\rho_{l0} = \frac{2\pi\epsilon_0 V_0}{\ln\left(\frac{2h-a}{a}\right)}$$

$$q' = -q \left(\frac{\epsilon_r - 1}{\epsilon_r + 1} \right)$$

$$q'' = q \left(\frac{2\epsilon_r}{\epsilon_r + 1} \right)$$

$$C = \frac{Q}{V} = \frac{Q_A}{V_{AB}}$$

$$C = \frac{2U_E}{V^2}$$

$$U_E = \frac{1}{2} \int_V \underline{D} \cdot \underline{E} dV$$

$$U_E = \frac{1}{2} \int_V \rho_v \Phi dV \quad (\Phi(\infty) = 0)$$

$$U_E = \frac{1}{2} \int_S \rho_s \Phi dS \quad (\Phi(\infty) = 0)$$

$$U_E = \frac{1}{2} CV^2$$

$$U_E = \frac{1}{2} QV$$

Electrostatic Triangle

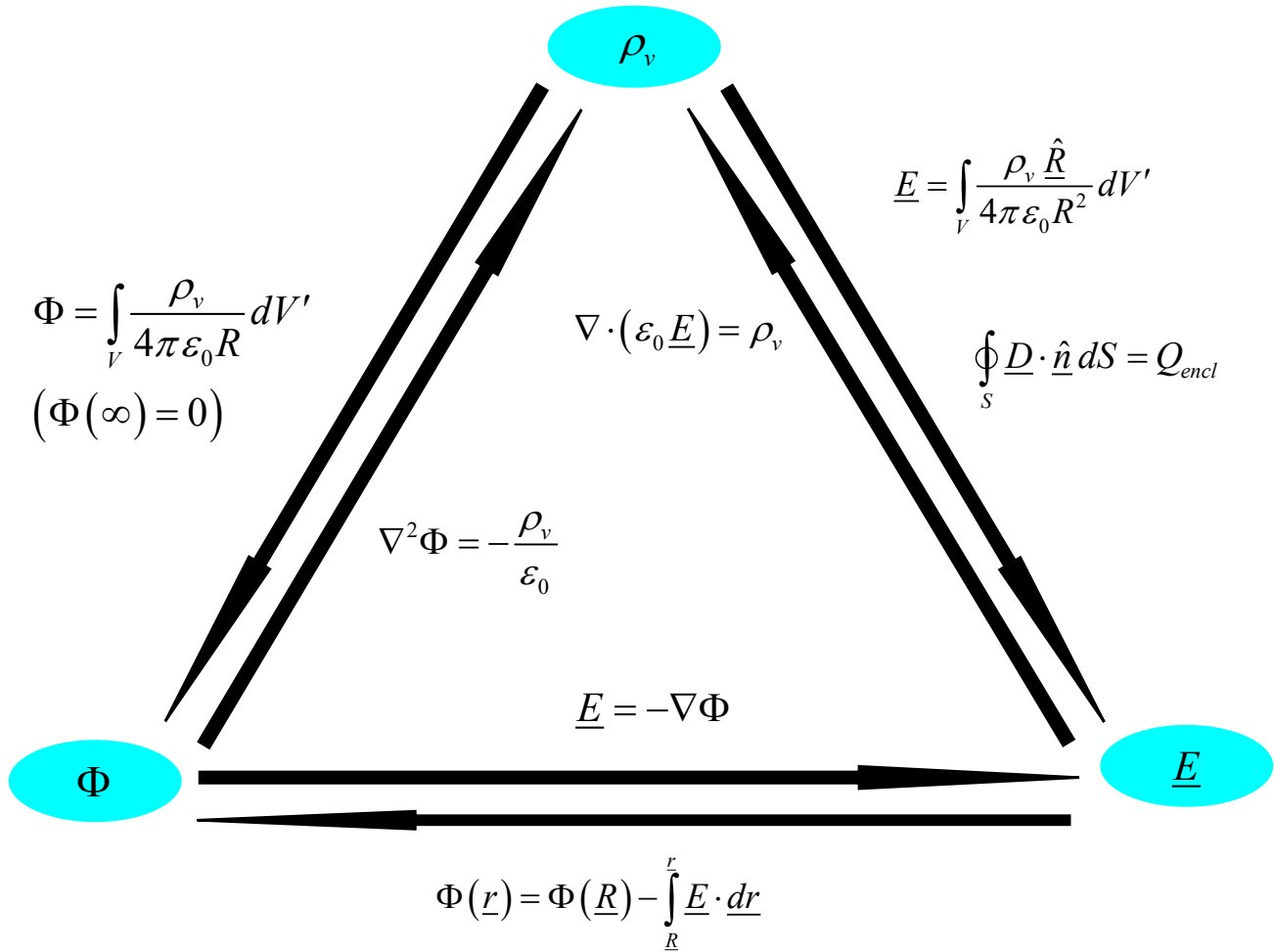


TABLE OF INTEGRALS

$$\int \frac{dx}{(x^2 + a^2)^{1/2}} = \ln(x + \sqrt{x^2 + a^2})$$

$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{x}{a^2 \sqrt{x^2 + a^2}}$$

$$\int \frac{x dx}{(x^2 + a^2)^{3/2}} = \frac{-1}{\sqrt{x^2 + a^2}}$$

$$\int \frac{x dx}{(x^2 + a^2)^{1/2}} = \sqrt{x^2 + a^2}$$

$$\int \frac{x^2 dx}{(x^2 + a^2)^{3/2}} = \frac{-x}{\sqrt{x^2 + a^2}} + \ln(x + \sqrt{x^2 + a^2})$$

$$\int \frac{x^2 dx}{(x^2 + a^2)^{1/2}} = \frac{x\sqrt{x^2 + a^2}}{2} - \frac{a^2}{2} \ln(x + \sqrt{x^2 + a^2})$$

$$\int x(x^2 + a^2)^{3/2} dx = \frac{1}{5}(x^2 + a^2)^{5/2}$$

$$\int (x^2 + a^2)^{3/2} dx = \frac{x(x^2 + a^2)^{3/2}}{4} + \frac{3a^2 x \sqrt{x^2 + a^2}}{8} + \frac{3}{8} a^4 \ln(x + \sqrt{x^2 + a^2})$$

TABLE OF COORDINATE SYSTEM FORMULAS

$$x = \rho \cos \phi$$

$$y = \rho \sin \phi$$

$$z = z$$

$$\underline{\hat{r}} \cdot \underline{\hat{x}} = \sin \theta \cos \phi = x / r$$

$$\underline{\hat{r}} \cdot \underline{\hat{y}} = \sin \theta \sin \phi = y / r$$

$$\underline{\hat{r}} \cdot \underline{\hat{z}} = \cos \theta = z / r$$

$$x = r \sin \theta \cos \phi$$

$$y = r \sin \theta \sin \phi$$

$$z = r \cos \theta$$

$$\underline{\hat{\rho}} \cdot \underline{\hat{x}} = \cos \phi$$

$$\underline{\hat{\phi}} \cdot \underline{\hat{x}} = -\sin \phi$$

$$\rho = \sqrt{x^2 + y^2}$$

$$\phi = \tan^{-1}(y/x)$$

$$z = z$$

$$\rho = r \sin \theta$$

$$z = r \cos \theta$$

$$\phi = \phi$$

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$\theta = \cos^{-1}\left(z / \sqrt{x^2 + y^2 + z^2}\right)$$

$$\phi = \tan^{-1}(y/x)$$

$$r = \sqrt{\rho^2 + z^2}$$

$$\theta = \tan^{-1}(\rho/z)$$

$$\phi = \phi$$