Constants: $k_e = 8.99\times10^9 Nm^2/C^2$ $\varepsilon_o = \frac{1}{4\pi k_e} = 8.85\times10^{-12} F/m$ $e = 1.602\times10^{-19} C$

$m_e = 9.11\times10^{-31} kg$ $m_p = 1.67\times10^{-27} kg$ $N_A = 6.02\times10^{23} items/mole$ $G = 6.67\times10^{-11} Nm^2/kg^2$

Dielectric strength of air = 30,000 V/cm = 3 MV/m

Electric Field:

$\vec{\mathbf{F}}_{q_o} = q_o \vec{\mathbf{E}}(\vec{\mathbf{r}}_{q_o})$ $\vec{\mathbf{E}}(\vec{\mathbf{r}}_o) = k_e \sum_i \frac{Q_i}{r_{io}^2}\hat{\mathbf{r}}_{io}$ $\vec{\mathbf{E}}(\vec{\mathbf{r}}_o) = k_e \int_{\substack{charge\\distribution}} \frac{dq}{r_{qo}^2}\hat{\mathbf{r}}_{qo}$ $\vec{\mathbf{E}}_{point}(\vec{\mathbf{r}}) = \frac{k_e q}{r^2}\hat{\mathbf{r}}$ $E_{line} = \frac{2k_e q}{r}\hat{\mathbf{r}}$ $\vec{\mathbf{E}}_{plane}(\vec{\mathbf{r}}) = \frac{\sigma}{2\varepsilon_o}(out)$

Electric Potential & Potential Energy

$\Delta U = q\Delta V = -W_{by\ field}$ $\Delta U = U_b - U_a = -\int_a^b \vec{\mathbf{F}}\bullet d\vec{\ell}$

$U_{\substack{2\,point\\charges}} = \frac{q_1 q_2}{r_{12}}$ $\Delta V = V_b - V_a = -\int_a^b \vec{\mathbf{E}}\bullet d\vec{\ell}$ $E_x = -\frac{\partial V}{\partial x}$ $V_{point}(r) = \frac{k_e q}{r} - \frac{k_e q}{R_{ref}}$ $V_{line}(R) = 2k_e\lambda \ln\frac{R_{ref}}{R}$ $V(r) = k_e \int_{\substack{charge\\distribution}} \frac{dq}{r}$

Conductor at Equilibrium

E = 0 *inside*; $E = \frac{\sigma_{surface}}{\varepsilon_o}$ *just outside; V = constant..*

Gauss' Law and Coulomb's Law

$\vec{\mathbf{F}}_{12} = k_e \frac{q_1 q_2}{r_{12}^2}\hat{\mathbf{r}}_{12};$ $\vec{\mathbf{r}}_{12} = \vec{\mathbf{r}}_1 - \vec{\mathbf{r}}_2$ $\Phi_e = \iint \vec{\mathbf{E}}\bullet d\vec{\mathbf{A}} = \iint (\vec{\mathbf{E}}\bullet\hat{\mathbf{n}})dA$ $\Phi_{net} = \iint_{\substack{closed\\surface}} \vec{\mathbf{E}}\bullet d\vec{\mathbf{A}} = \frac{q_{enclosed}}{\varepsilon_o} = \frac{1}{\varepsilon_o}\iiint_{\substack{enclosed\\volume}} \rho\, dV$

Circuits: Capacitance, Current and Resistance

$Q = CV$ **;** $U = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$ $C_{parallel} = C_1 + C_2$ $C_{series} = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)^{-1}$

parallel plate: $C_{pp} = \frac{\kappa\varepsilon_o A}{d}$; coaxial cable: $C_{coax} = \frac{2\pi\kappa\varepsilon_o L}{\ln\left(R_2/R_1\right)}$; isolated sphere: $C_{sphere} = 4\pi\kappa\varepsilon_o R$

$I = GV = \frac{V}{R}$ **;** $Power = I^2R = IV = \frac{V^2}{R}$ **;** $G = \frac{\sigma A}{L}$ **;** $R = \frac{1}{G} = \rho\frac{L}{A}$ $R_{parallel} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1}$ $R_{series} = R_1 + R_2$

$\sum_{\substack{closed\\loop}} \Delta V = 0$ $\sum_{point} I = 0$ *I same in series;* ΔV *same in parallel* $\vec{\mathbf{J}} = nq\vec{\mathbf{v}}_{drift}$ $I = \iint \vec{\mathbf{J}}\bullet d\vec{\mathbf{A}}$

Geometry and Definitions: Surface Area: $A_{sphere} = 4\pi R^2$ $A_{cyl} = 2\pi RH + 2\pi R^2$ $A_{cube} = 6a^2$

Volume: $V_{sphere} = \frac{4}{3}\pi R^3$ $V_{cyl} = \pi R^2 H$ $V_{cube} = a^3$

Linear Charge Density: $\lambda = \frac{Q}{length}$; Areal Charge Density: $\sigma = \frac{Q}{Area}$;

Volume Charge Density $\rho = \frac{Q}{volume}$ $\cos 30° = \frac{\sqrt{3}}{2}; \sin 30° = \frac{1}{2}; \cos 45° = \sin 45° = \frac{\sqrt{2}}{2}$

Kinematics

$\vec{\mathbf{a}} = \frac{\vec{\mathbf{F}}}{m} = \frac{q}{m}\vec{\mathbf{E}}$ $x = x_o + v_o t + \frac{1}{2}at^2$ $v = v_o + at$