Mathematical:

Sphere: $V = \frac{4}{3}\pi r^3 \quad A = 4\pi r^2$

Spherical shell: $V = \frac{4\pi\left(b^3 - a^3\right)}{3}$

Cylinder: (area of ends not included)

$V = \pi r^2 h \quad A = 2\pi r h$

Pipe $V = \pi L\left(b^2 - a^2\right)$:

dot product:

$\vec{A}\cdot\vec{B} = AB\cos\theta$

$\vec{A}\cdot\vec{B} = A_x B_x + A_y B_y + A_z B_z$

$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1$

$\hat{i}\cdot\hat{j} = \hat{i}\cdot\hat{k} = \hat{j}\cdot\hat{k} = 0$

vector cross product:

$\vec{C} = \vec{A}\times\vec{B}$

$C = AB\sin\theta$

$\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$

$\hat{i}\times\hat{j} = \hat{k}, \hat{j}\times\hat{k} = \hat{i}, \hat{k}\times\hat{i} = \hat{j}$

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

23 Electric Fields

$\vec{F}_{12} = k\frac{q_1 q_2}{r^2}\hat{r} \quad ; \quad F_{12} = k\frac{|q_1||q_2|}{r^2}$

where

$k = 9\times 10^9$ Nm^2/C^2 and $k = \frac{1}{4\pi\varepsilon_0}$

$\varepsilon_0 = 8.85\times 10^{-12}$ C^2/N.m^2

$\vec{E} = \frac{kq\hat{r}}{r^2}$

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

$\rho = \frac{dQ}{dV}; \sigma = \frac{dQ}{dA}; \lambda = \frac{dQ}{dl}$

24 Gauss' Law

$\Phi = \int \vec{E}\cdot d\vec{A} = \int E\cos\theta\, dA$

$\Phi_c = \oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}$

$E = \frac{\sigma}{2\varepsilon_0}$ (plane sheet)

$E_n = \frac{\sigma}{\varepsilon_0}$ (just outside cond.)

25 Electric Potential

$V_B - V_A = -\int_A^B \vec{E}\cdot d\vec{s}$

$\Delta U = q\Delta V$

$\Delta K + \Delta U = W_{other}$

for reference point at infinity:

$V = k\sum_i \frac{q_i}{r_i}$ (potl. of pt. chgs.)

and,

$V = k\int \frac{dq}{r}$

$E_x = -\frac{\partial V}{\partial x}, E_y = -\frac{\partial V}{\partial y}, E_z = -\frac{\partial V}{\partial z}$

26 Capacitance and Dielectrics

$C = \frac{Q}{\Delta V}$

$C = \frac{\varepsilon_0 A}{d}$ (parallel plate)

$C = \frac{l}{2k\ln\left(\frac{b}{a}\right)}$ (cylindrical)

$C_{eq} = \sum_i C_i$ (parallel)

$\frac{1}{C_{eq}} = \sum_i \frac{1}{C_i}$ (series)

$U = \frac{1}{2}Q\Delta V$

$u = \frac{1}{2}\varepsilon_0 E^2$

$C = KC_0$

27 Current and Resistance

$I = \frac{dQ}{dt} = nqv_d A$

$\vec{J} = nq\vec{v}_d$

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

$\Delta V = IR$

$R = \rho\frac{l}{A}$

$\alpha = \frac{1}{\rho_0}\frac{\Delta\rho}{\Delta T}$

$P = \Delta VI$

28 DC Circuits

$R_{eq} = \sum_i R_i$ series

$\frac{1}{R_{eq}} = \sum_i \frac{1}{R_i}$ parallel

$\sum I_{in} = \sum I_{out}$ (K.L. #1)

$\sum_{loop} \Delta V = 0$ (K.L. #2)

$q(t) = Q\left[1 - e^{-t/RC}\right]$

$q(t) = Qe^{-t/RC}$

29 Magnetic Fields

$\vec{F} = q\vec{v}\times\vec{B}$

$d\vec{F} = Id\vec{L}\times\vec{B}; \quad \vec{F} = I\int d\vec{L}\times\vec{B}$

$\vec{F} = I\vec{l}\times\vec{B}$ straight wire

$V_H = \frac{IB}{nqt}$ Hall voltage

30 Sources of Magnetic Fields

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

$\mu_0 = 4\pi\times 10^{-7}\frac{W}{A.m}$

Field magnitude at (0,a,0) of a straight wire with ends at x=L_1 and L_2:

$B = \frac{\mu_0 I}{4\pi a}\left|\frac{L_2}{\sqrt{L_2^2 + a^2}} - \frac{L_1}{\sqrt{L_1^2 + a^2}}\right|$

or in terms of angles as used in Serway:

$B = \frac{\mu_0 I}{4\pi a}\left(\cos\theta_1 - \cos\theta_2\right)$

$B = \frac{\mu_0 IR^2}{2\left(R^2 + x^2\right)^{3/2}}$ (on axis of current loop)

$B = \frac{\mu_0 I}{2\pi r}$

$\oint \vec{B}\cdot d\vec{s} = \mu_0 I$

$\Phi_m = \int \vec{B}\cdot d\vec{A}$

$\Phi_m = BA\cos\theta$ (constant **B)**

$\oint \vec{B}\cdot d\vec{A} = 0$

31 Faraday's Law

$Emf = -\frac{d\Phi_m}{dt}$

$\Delta V = Blv$ moving bar

$\oint \vec{E}\cdot d\vec{s} = -\frac{d\Phi_m}{dt}$

Maxwells Equations for vacuum:

$\oint \vec{E}\cdot d\vec{A} = \frac{Q}{\varepsilon_0}$

$\oint \vec{B}\cdot d\vec{A} = 0$

$\oint \vec{E}\cdot d\vec{s} = -\frac{d\Phi_m}{dt}$

$\oint \vec{B}\cdot d\vec{s} = \mu_0 I + \varepsilon_0\mu_0\frac{d\Phi_e}{dt}$

32 Inductance

$L = \frac{N\Phi}{I}$

$\mathcal{E} = -L\frac{dI}{dt}$

$M_{12} = \frac{N_2\Phi_{12}}{I_1}$

$I = \frac{\mathcal{E}}{R}\left(1 - e^{-\frac{t}{\tau}}\right)$

$\tau = \frac{L}{R}$

$I = I_0 e^{-\frac{t}{\tau}}$