Exam 2: Electrostatics & Currents
(**boldfaced** symbols denote vectors)

Electrostatics

$$\mathbf{F}_{12} = \frac{kQ_1Q_2}{r^2}\hat{\mathbf{r}}_{12}$$
$$\mathbf{F} = q\mathbf{E}$$
$$\mathbf{E} = \frac{kQ}{r^2}\hat{\mathbf{r}}$$

Various electric field configurations:

$$\begin{aligned} E &= kQ\frac{x}{(x^2+a^2)^{3/2}} \\ &= \frac{\sigma}{2\epsilon_0}\left(1-\frac{x}{\sqrt{x^2+R^2}}\right) \\ &= \frac{\sigma}{2\epsilon_0} \\ &= \frac{\sigma}{\epsilon_0} \\ &= \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r} \\ &= \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2} \\ &= \frac{1}{4\pi\epsilon_0}\frac{Qr}{R^3} \end{aligned}$$

Flux and Gauss' Law

$$\begin{aligned} \Phi_e &= EA\cos\theta \\ &= \int \mathbf{E}\cdot d\mathbf{A} \\ &= \frac{Q_{enc}}{\epsilon_0} \end{aligned}$$

Potential and potential energy

$$\begin{aligned} U &= -q\int \mathbf{E}\cdot d\mathbf{s} \\ &= qV \\ V &= -\int \mathbf{E}\cdot d\mathbf{s} \end{aligned}$$

$$\begin{aligned} E_i &= -\frac{\partial}{\partial x_i}V(x) \\ \mathbf{E} &= -\nabla V \end{aligned}$$

Special cases:

$$\begin{aligned} V &= -\mathbf{E}\cdot\mathbf{s} \\ &= \frac{kQ}{r} \\ E &= V/R \end{aligned}$$

Capacitance

$$C = \frac{Q}{\Delta V}$$
$$C = \frac{\epsilon_0 A}{d}$$
$$C = \kappa C_0$$
$$C_{eq} = C_1 + C_2$$
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$
$$U = \frac{Q^2}{2C} = \frac{C(\Delta V)^2}{2}$$
$$u = \frac{\epsilon_0}{2}E^2$$
$$\Delta V = E\,d$$
$$E = \frac{\sigma}{\epsilon_0}$$

Currents and Circuits

Microscopic view of currents:

$$v_d = \frac{I}{A}\frac{1}{en}$$

$$\mathbf{J} = \sigma \mathbf{E} = \mathbf{E}/\rho$$

Macroscopic view of currents:

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

$$\Delta V = IR$$

Power:

$$\begin{aligned} P &= IV \\ &= I^2 R \\ &= \frac{V^2}{R} \end{aligned}$$

Circuits

$$R_{eq} = R_1 + R_2$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\Delta V = \varepsilon - IR_{int}$$

$$I = \frac{dQ}{dt} = C\frac{dV}{dt}$$

$$Q = CV$$

time constant $\tau = RC$

$$q(t) = C\varepsilon(1 - e^{-t/RC})$$

$$I(t) = \frac{\varepsilon}{R}e^{-t/RC}$$

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

$$I(t) = -\frac{Q}{RC}e^{-t/RC}$$

Constants, etc:

$$\begin{aligned} q_e &= -1.6 \times 10^{-19} C \\ k &= 8.99 \times 10^9 Nm^2/C^2 \\ &= \frac{1}{4\pi\epsilon_0} \\ \epsilon_0 &= 8.85 \times 10^{-12} C^2/Nm^2 \end{aligned}$$

I would also include properties of conductors on my cheat sheet and other qualitative results we discussed, for example where is high potential and low potential, in which direction does the electric field point etc....... Besides you need to know geometric formulas for spheres, cyliders etc.