Exam II Equation Review

Ch. 24 Capacitance

- Capacitance: $q = CV$
- Method for finding capacitance applied to parallel-plate, cylindrical capacitor, spherical capacitor, isolated sphere.
- Parallel Capacitors: $C_{eq} = \sum C_j$
- Series Capacitors: $\frac{1}{C_{eq}} = \sum_j \frac{1}{C_j}$
- Energy stored in capacitor: $U = \frac{1}{2}CV^2$

Ch. 25 Current and Resistance

- $i = \frac{dq}{dt}$
- Current density: $i = \int \vec{J} \cdot d\vec{A}$
- Current and Drift speed: $\vec{J} = (nq)\vec{v_d}$ and $i = nqv_dA$
- Resistance: $R = \frac{V}{i}$; Resistivity: $\rho = \frac{E}{J}$
- $R = \rho\frac{L}{A}$
- Power in electric circuits: $P = iV$ Also $P = i^2R = V^2/R$

Ch. 26 DC Circuits

- EMF $= \varepsilon =$ open circuit voltage of battery.
- $\Delta V = \varepsilon - Ir$ terminal voltage across battery with internal resistance r.
- Resistors in series: $R_{eq} = R_1 + R_2 + ...$
- Resistors in parallel: $1/R_{eq} = 1/R_1 + 1/R_2 + ...$
- Kirchhoff's Rules.
  - Junction Rule: $\Sigma_{junction} I = 0$
  - Loop Rule: $\Sigma_{closedloop} \Delta V = 0$
- RC Circuits
  - Charging current: $I(t) = I_0 e^{-t/RC}$
  - Charging charge: $q(t) = Q_{max}(1 - e^{-t/RC})$, where $Q_{max} = C\varepsilon$
  - Discharging current: $I(t) = I_0 e^{-t/RC}$
  - RC time constant, $\tau = RC$, is time to change by 63%.

Ch. 27 Magnetic Fields

- $\vec{F_B} = q\vec{v} \times \vec{B}$
- Electric and Magnetic combined: $\vec{F_B} = q(\vec{E} + \vec{v} \times \vec{B})$

- Circulating charged particle: $qvB = \frac{mv^2}{r}$
- Circulating charged particle: $\omega = \frac{qB}{m}$
- Helical paths: $v_\perp = v \sin\phi$
- Force on current carrying wire: $\vec{F_B} = i\vec{L} \times \vec{B}$
- Applications: mass spectrometer, velocity selector

Ch. 28 Sources of Magnetic Fields

- Biot-Savart Law
$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{id\vec{s} \times \vec{r}}{r^3} \quad OR \quad d\vec{B} = \frac{\mu_0}{4\pi}\frac{id\vec{s} \times \hat{r}}{r^2}$$
- Right-hand rule for cross products (like $d\vec{s} \times \vec{r}$ and $\vec{v} \times \vec{B}$)
- Right-hand rule for finding direction of $\vec{B}$ around wires.
- $\rightarrow$ thumb points in direction of current
- B-field for long straight wire: $B = \frac{\mu_0 i}{2\pi R}$
- B-field at center of circular arc: $B = \frac{\mu_0 i\phi}{4\pi R}$
- Force between two parallel currents: $\vec{F}_{ba} = i_b\vec{L} \times \vec{B}_a$
- $\rightarrow$ since B_a is $\frac{\mu_0 i_a}{2\pi d}$,
- $\rightarrow F_{ba} = \frac{\mu_0 i_a i_b L}{2\pi d}$ (direction determined by RHR or remember "opposites repel".)
- Ampere's Law
$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$$
- Solenoids and Toroids
- B-field in ideal solenoid: $B = \mu_0 in$
- B-field in toroid: $B = \frac{\mu_0 iN}{2\pi r}$
- A current-carrying coil as a magnetic dipole: $\vec{\mu} = NiA$
- Gauss's law of magnetism: $\oint \vec{B} \cdot d\vec{A} = 0$

Ch. 29 Faraday's Law of Induction

- Faraday's Law: $\varepsilon = -d\Phi_B/dt$ (EMF around loop of wire.)
- Faraday's Law, N loops: $\varepsilon = -Nd\Phi_B/dt$
- Motional EMF: $\Delta V = Blv$ between top and bottom of conducting bar moving at constant v through uniform $\perp$ B
- Faraday's Law, general, no wire needed: $\oint \vec{E} \cdot d\vec{s} = -d\Phi_B/dt$
- Generators: EMF generated by loop rotating in uniform B: $\varepsilon = NAB\omega \sin\omega t$
- Motors have the same mechanical structure as a generator, but are run "in reverse" (i.e., current pushed through a loop causing the loop to turn).