Physics 135-2 **Equation Sheet** **Winter 2014**

Final Exam

Kinematics: $v = v_o + at$; $\Delta x = v_o t + (½) a t^2$; $v^2 = v_o^2 + 2a(x - x_o)$

Kinetic Energy: $K = \frac{1}{2}mv^2$

Coulomb's law: $F = k\frac{|q_1||q_2|}{r^2} = \frac{1}{4\pi\varepsilon_o}\frac{|q_1||q_2|}{r^2}$

Electric Field: $\vec{E} = \frac{\vec{F}}{q_o}$ $\quad E = \frac{1}{4\pi\varepsilon_o}\frac{|q|}{r^2}$

Gauss's Law for E: $\varepsilon_o\Phi_E = q_{enc}$ where $\Phi_E = \oint \vec{E}\cdot d\vec{A}$

Gauss's Law for B: $\Phi_B = \oint \vec{B}\cdot d\vec{A} = 0$

Potential Difference: $\Delta V = \frac{\Delta U}{q} = -\frac{W}{q} = V_f - V_i = -\int_i^f \vec{E}\cdot d\vec{l}$

Potential (point charge): $V = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$

E from *V*: $\vec{E} = -\frac{\partial V}{\partial x}\hat{i} - \frac{\partial V}{\partial y}\hat{j} - \frac{\partial V}{\partial z}\hat{k}$

Electric Potential Energy: $U = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_2}{r}$ (Pair of point charges)

Capacitors: $q = CV$ & $U_E = \frac{1}{2}CV^2 = \frac{q^2}{2C}$ (in general)

$C = \frac{\varepsilon_o A}{d}$ (parallel-plate capacitor) $\quad E = \frac{V}{d}$

$C_{eq} = \sum_{j=1}^{n} C_j$ (paral $\frac{1}{C_{eq}} = \sum_{j=1}^{n}\frac{1}{C_j}$ (series)

Current: $i = \frac{dq}{dt} = \int \vec{j}\cdot d\vec{A}$ where $\vec{j} = (ne)\vec{v}_d$

Resistance: $R = \frac{V}{i}$ $\quad \rho = \frac{E}{j}$ $\quad R = \rho \frac{l}{A}$

Power: $P = iV = i^2 R = \frac{V^2}{R}$

Resistors: $R_{eq} = \sum_{j=1}^{n} R_j$ (series $\frac{1}{R_{eq}} = \sum_{j=1}^{n} \frac{1}{R_j}$ (parallel)

RC Circuits: $q = q_o e^{-t/RC}$ (discharging) $\quad i = -\left(\frac{q_o}{RC}\right) e^{-t/RC}$ (discharging)

Magnetic Force/Torque: $\vec{F}_B = q\vec{v} \times \vec{B}$ $\quad \vec{F}_B = i\vec{l} \times \vec{B}$ $\quad \vec{\tau} = \vec{\mu} \times \vec{B}$ $\quad |\vec{\mu}| = NiA$

Circulating Charge: $qvB = \frac{mv^2}{r}$ $\quad f = \frac{1}{T} = \frac{qB}{2\pi m}$

Biot-Savart Law: $d\vec{B} = \frac{\mu_o}{4\pi} \frac{i d\vec{l} \times \hat{r}}{r^2}$ or $dB = \frac{\mu_o}{4\pi} \frac{idl \sin\theta}{r^2}$

Ampere's Law: $\oint \vec{B} \cdot d\vec{l} = \mu_o (i_c + i_d)$ where $i_d = \varepsilon_o \frac{d\Phi_E}{dt}$

Solenoid: $B = \mu_o i n$ $\quad L = \mu_o \pi n^2 R^2 l$ $\quad n = N/l$

Faraday's Law: $\varepsilon = \oint \vec{E} \cdot d\vec{s} = -N \frac{d\Phi_B}{dt}$ $\quad \Phi_B = \int \vec{B} \cdot d\vec{A}$ $\quad \varepsilon = vBL$

Inductors: $\mathrm{L} = \frac{N\Phi_B}{i}$ $\quad \varepsilon_L = -\mathrm{L}\frac{di}{dt}$ $\quad U_B = \frac{1}{2}\mathrm{L}i^2$ $\quad u_B = \frac{B^2}{2\mu_o}$

RL Circuits: $i = \frac{\varepsilon}{R}\left(1 - e^{-(R/L)t}\right)$ or $i = I_o e^{-(R/L)t}$

Constants:
$c = 3.00 \times 10^8$ m/s (speed of light)
$k = 1/4\pi\varepsilon_o = 8.99 \times 10^9$ N $\cdot$ m^2/C^2
$\varepsilon_o = 8.85 \times 10^{-12}$ C^2 /N $\cdot$ m^2
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)
$e = 1.6 \times 10^{-19}$ C (charge on electron)
$\mu_o = 4\pi \times 10^{-7}$ T $\cdot$ m/A
g = 9.81 m/s^2

Conversions:
1 MΩ = 10^{+6} Ω $\quad$ 1 gram = 10^{-3} kg $\quad$ 1 mT = 10^{-3} T $\quad$ 1 kV = 1000 V
1 m = 10^2 cm = 10^3 mm = 10^6 μm = 10^9 nm $\quad$ 1 eV = 1.6×10^{-19} J

Geometry:
S (cylinder) = $2\pi rL + 2\pi r^2$ $\quad$ S (sphere) = $4\pi r^2$ $\quad$ A (circle) = πr^2
V (cylinder) = $\pi r^2 L$ $\quad$ V (sphere) = $(4/3)\pi r^3$ $\quad$ C (circle) = $2\pi r$

Calculus: $\frac{d}{dx}\ln x = x^{-1}$ $\quad \int \frac{dx}{x} = \ln x$ $\quad \int x^n dx = x^{n+1}/(n+1)$ $\quad \frac{d}{dx}e^u = e^u \frac{du}{dx}$