PHYSICS 2B FINAL EXAM WINTER QUARTER 2010
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Formulas:

$\sin 30^\circ = \cos 60^\circ = 1/2, \quad \cos 30^\circ = \sin 60^\circ = \sqrt{3}/2, \quad \sin 45^\circ = \cos 45^\circ = \sqrt{2}/2$

$F = k\frac{q_1 q_2}{r^2}$ Coulomb's law ; $k = 9\times 10^9 \mathrm{N\cdot m^2/C^2}$; $\vec{F}_{12} = \frac{k q_1 q_2}{|\vec{r}_2 - \vec{r}_1|^3}(\vec{r}_2 - \vec{r}_1)$

Electric field due to charge q at distance r: $\vec{E} = \frac{kq}{r^2}\hat{r}$; Force on charge Q: $\vec{F} = Q\vec{E}$

Electric field of dipole: along dipole axis / perpendicular: $E = \frac{2kp}{x^3}$ / $E = \frac{kp}{y^3}$ (p=qd)

Energy of and torque on dipole in E-field: $U = -\vec{p}\cdot\vec{E}$, $\vec{\tau} = \vec{p}\times\vec{E}$

Linear, surface, volume charge density: $dq = \lambda\, ds$, $dq = \sigma\, dA$, $dq = \rho\, dV$

Electric field of infinite: line of charge: $E = \frac{2k\lambda}{r}$; sheet of charge: $E = 2\pi k\sigma = \sigma/(2\varepsilon_0)$

Gauss law: $\Phi = \oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$; Φ = electric flux ; $k = \frac{1}{4\pi\varepsilon_0}$; $\varepsilon_0 = 8.85\times 10^{-12} C^2/Nm^2$

$U_B - U_A = \Delta U_{AB} = -W_{AB} = -\int_A^B \vec{F}\cdot d\vec{l} = -\int_A^B q\vec{E}\cdot d\vec{l} = q\Delta V_{AB} = q(V_B - V_A)$ V=N/C

$V = \frac{kq}{r}$; $V = \int \frac{k\,dq}{r}$; $V = \frac{kp\cos\theta}{r^2}$ (dipole) ; $E_l = -\frac{\partial V}{\partial l}$; $\vec{E} = -\vec{\nabla} V$

Electrostatic energy: $U = k\frac{q_1 q_2}{r}$; Capacitors: $Q = CV$; with dielectric: $C = \kappa C_0$; $\varepsilon_0 = 8.85\,pF/m$

$C = \frac{\varepsilon_0 A}{d}$ parallel plates ; $C = \frac{2\pi\varepsilon_0 L}{\ln(b/a)}$ cylindrical ; $C = 4\pi\varepsilon_0\frac{ab}{b-a}$ spherical

Energy stored in capacitor: $U = \frac{Q^2}{2C} = \frac{1}{2}QV = \frac{1}{2}CV^2$; $U = \int dv\, u_E$; $u_E = \frac{1}{2}\varepsilon_0 E^2$

Capacitors in parallel: $C = C_1 + C_2$; in series: $C = C_1 C_2/(C_1 + C_2)$

Elementary charge: $e = 1.6\times 10^{-19} C$

$I = \frac{dq}{dt} = \int \vec{J}\cdot d\vec{A}$; $\vec{J} = ne\vec{v}_d$; $v_d = \frac{eE\tau}{m}$; $\rho = \frac{m}{ne^2\tau}$; $R = \rho\frac{\ell}{A}$; $\vec{E} = \rho\vec{J}$, $\vec{J} = \sigma\vec{E}$

$V = IR$; $P = VI = I^2 R = V^2/R$; $P_{emf} = \varepsilon I$; $R_{eq} = R_1 + R_2$ (series) ; $R_{eq}^{-1} = R_1^{-1} + R_2^{-1}$ (parallel)

Charging capacitor: $Q(t) = C\varepsilon(1 - e^{-t/RC})$; Discharging capacitor: $Q(t) = Q_0 e^{-t/RC}$

Force on moving charge: $\vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$; force on wire: $d\vec{F} = I d\vec{\ell}\times\vec{B}$

Circular motion: $a = \frac{v^2}{r}$; radius $r = \frac{mv}{qB}$; period $T = \frac{2\pi\,\mathrm{m}}{\mathrm{qB}}$

Magnetic dipole: $\vec{\mu} = I\vec{A}$; torque: $\vec{\tau} = \vec{\mu}\times\vec{B}$; energy: $U = -\vec{\mu}\cdot\vec{B}$

Biot-Savart law: $d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{\ell}\times\hat{r}}{r^2}$; $\mu_0 = 4\pi\times 10^{-7}\frac{N}{A^2}$; Ampere's law: $\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I_{enc}$

Long wire: $B = \frac{\mu_0 I}{2\pi r}$; loop, along axis: $B = \frac{\mu_0 I a^2}{2(a^2 + z^2)^{3/2}}$; dipole: $\vec{B} = \frac{\mu_0}{2\pi}\frac{\vec{\mu}}{x^3}$

solenoid: $B = \mu_0 I n$; toroid: $B = \frac{\mu_0 N I}{2\pi r}$; Gauss law for magnetism: $\oint \vec{B}\cdot d\vec{A} = 0$

Faraday law: $\varepsilon = -\frac{d\Phi_B}{dt} = \oint \vec{E}\cdot d\vec{s}$; $\Phi_B = \int \vec{B}\cdot d\vec{A}$ magnetic flux

Mutual inductance: $M = \frac{\Phi_2}{I_1} = \frac{\Phi_1}{I_2}$; $\varepsilon_2 = -M\frac{dI_1}{dt}$; $\varepsilon_1 = -M\frac{dI_2}{dt}$

Self - inductance: $L = \frac{\Phi_B}{I}$; $\varepsilon_L = -L\frac{dI}{dt}$; $L = \mu_0 n^2 A\ell$ for solenoid

Magnetic energy: $U_B = \frac{1}{2}LI^2$; $u_B = \frac{B^2}{2\mu_0}$

RL circuit: $I = \frac{\varepsilon}{R}(1 - e^{-t/\tau_L})$ (rise) ; $I = I_0 e^{-t/\tau_L}$ (decay) ; $\tau_L = L/R$

LC oscillations: $q(t) = q_p\cos(\omega_0 t)$; $I(t) = -\omega_0 q_p \sin(\omega_0 t)$; $\omega_0 = \frac{1}{\sqrt{LC}}$

Alternating emf, RLC: $V = V_p \sin\omega t$; $I = I_p\sin(\omega t - \phi)$; $I_p = V_p/Z$; $\tan\phi = \frac{X_L - X_C}{R}$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$; Voltage amplitudes: $V_R = IR,\ V_L = IX_L,\ V_C = IX_C$; $X_L = \omega L,\ X_C = \frac{1}{\omega C}$

Ampere - Maxwell law: $\oint \vec{B}\cdot dl = \mu_0 I_{enc} + \mu_0\varepsilon_0\frac{d\phi_E}{dt}$; displacement current $I_d = \varepsilon_0\frac{d\phi_E}{dt}$; $\phi_E = \int \vec{E}\cdot d\vec{A}$

Electromag. waves: $\vec{E} = E_p\sin(kx - \omega t)\hat{j}$; $\vec{B} = B_p\sin(kx - \omega t)\hat{k}$; $\frac{E_p}{B_p} = \frac{\omega}{k} = c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3\times 10^8 m/s$

$k = 2\pi/\lambda$, $\omega = 2\pi f$