PHYS2326 – Formula Sheet

Useful values:

$\epsilon_0 = 8.85\times10^{-12}\frac{C^2}{Nm^2}$

$m_e = 9.11\times10^{-31}kg$

$m_p = 1.67\times10^{-27}kg$

$q_e = e = 1.60\times10^{-19}C$

$\rho_{copper} = 1.72\times10^{-8}\ \Omega m$

$\mu_0 = 4\pi\times10^{-7}\ Tm/A$

$g = 9.81\ m/s^2$

Kinematics

$v_x = v_{0x} + a_x\Delta t$

$v_x^2 = v_{0x}^2 + 2a_x\Delta x$

$\Delta x = v_{0x}\Delta t + \frac{1}{2}a_x\Delta t^2$

$\Delta x = \frac{1}{2}(v_{0x} + v_x)\ \Delta t$

Ch. 21: Charge and E-field

$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{|q_1||q_2|}{r^2}\hat{r}$

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

$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{|q_1|}{r^2}\hat{r}$

- Electric dipole:

$\vec{p} = |q|\vec{d}$

$\vec{\tau} = \vec{p}\times\vec{E}$

$U = -\vec{p}\cdot\vec{E}$

- Electric field:

$\vec{E} = \frac{1}{4\pi\epsilon_0}\sum_{i=1}\frac{q_i}{r_i^2}\hat{r}_i$

$d\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{dq}{r^2}\hat{r}$

Ch. 22: Gauss's Law

$\Phi_E = \int \vec{E}\cdot d\vec{A}$

- Gauss's Law:

$\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0}$

Ch. 23: Electric potential

- Electric Potential energy:

$\Delta U = -W_E = -\int \vec{F}_E\cdot d\vec{s}$

$\Delta U = -\vec{F}_E\cdot\vec{d}$

$\Delta U = \left(\frac{qq_0}{4\pi\epsilon_0}\right)\left[\frac{1}{r_b} - \frac{1}{r_a}\right]$

$U = \frac{q_0}{4\pi\epsilon_0}\sum_{i=1}^{N}\frac{q_i}{r_i}$

- Electric potential:

$V = \frac{U}{q_0}$

$V = \frac{1}{4\pi\epsilon_0}\sum_{i=1}\frac{q_i}{r_i}$

$\Delta V = V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{s}$

$\vec{E} = -\vec{\nabla}V$

Ch. 24: Capacitance

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

$E = \frac{\sigma}{\epsilon_0}$ (Parallel-plate capacitor)

$C_{par-plates} = \frac{A}{d}\epsilon$

$C_{cylindrical} = \frac{2\pi\epsilon L}{\ln[\frac{r_b}{r_a}]}$

$C_{spherical} = \frac{4\pi\epsilon r_a r_b}{r_b - r_a}$

$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV = \frac{1}{2}CV^2$

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

$K = \frac{\epsilon}{\epsilon_0} = \frac{E_0}{E} = \frac{V_0}{V} = \frac{C}{C_0} = \frac{\sigma}{\sigma - \sigma_i}$

$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{encl}}{\epsilon}$

Ch. 25: I, R, and EMF

$I = \frac{dQ}{dt} = |q|Anv_D$

$|\vec{J}| = \frac{I}{A}$

$\vec{J} = \frac{\vec{E}}{\rho} = nq\vec{v}_D$

$\rho = \frac{1}{\sigma} = \frac{m}{nq^2\tau}$

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

$R = R_0[1 + \alpha(T - T_0)]$

$P = \frac{dU}{dt} = \mathrm{VI} = \mathrm{RI}^2 = \frac{\mathrm{V}^2}{R}$

Ch. 26: DC circuits

- RC Circuits:

$\tau = RC$

- Charging:

$q(t) = Q_f(1 - e^{-t/\tau})$

$i(t) = I_0 e^{-t/\tau}$

- Discharging:

$q(t) = Q_0 e^{-t/\tau}$

$i(t) = -I_0 e^{-t/\tau}$

Ch. 27: B-field and Forces

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

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

$\vec{\mu} = I\vec{A}$

$\vec{\tau} = \vec{\mu}\times\vec{B}$

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

- Gauss's Law for Magnetism:

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

- Charges in magnetic field:

$R = \frac{mv}{qB}$

$\omega = 2\pi f = \frac{v}{R} = \frac{qB}{m}$

Ch. 28: Sources of B-field

$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$

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

- Long wire:

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

- Current loop:

$B = \frac{\mu_0 I a^2}{2(a^2 + z^2)^{3/2}}$

- F between parallel conductors:

$F = \frac{\mu_0 L I_1 I_2}{2\pi r}$

- Ampere's Law:

$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{encl}$

- Ideal solenoid:

$B = \mu_0 nI$

- Toroid:

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

Ch. 29: EM induction

- Faraday's Law:

$\varepsilon = -\frac{d\Phi_B}{dt}$

$\oint \vec{E}\cdot d\vec{l} = -\frac{d\Phi}{dt}$

- Motional EMF:

$\varepsilon = vBL$