# Physics 4B Winter 2018 Sample Equation Sheet

March, 2018

Please show your work! Answer as many questions as you can, in any order. Calculators are allowed. Books, notes, and internet connectable devices are not allowed. Use any blank space to answer questions, but please make sure it is clear which question your answer refers to. When asked for an expression, give your answer only in terms of the variables given in the question and fundamental constants such as $g, k, e$, and so on.
**DO NOT OPEN TEST BOOKLET UNTIL TOLD TO DO SO.**

Maxwell's Equations

$$\oint \mathbf{E}\cdot \mathrm{d}\mathbf{A} = \frac{q_{\mathrm{enc}}}{\epsilon_0} \qquad \oint \mathbf{B}\cdot \mathrm{d}\mathbf{A} = 0$$

$$\oint \mathbf{E}\cdot \mathrm{d}\mathbf{s} = -\frac{\mathrm{d}\Phi_{\mathrm{B}}}{\mathrm{dt}} \qquad \oint \mathbf{B}\cdot \mathrm{d}\mathbf{s} = \mu_0\, I_{\mathrm{enc}} + \mu_0\epsilon_0 \frac{\mathrm{d}\Phi_{\mathrm{E}}}{\mathrm{dt}}$$

Constants

$k = \frac{1}{4\pi\epsilon_0} = 8.99\times 10^9\ \mathrm{Nm^2C^{-2}}$

$\epsilon_0 = 8.854\times 10^{-12}\ \mathrm{C^2\,N^{-1}m^{-2}}$

$\mu_0 = 4\pi\times 10^{-7}\ \mathrm{H/m}$

$g = 9.807\ \mathrm{m\,s^{-2}}$

$e = 1.602\times 10^{-19}\ \mathrm{C}$

$c = \frac{1}{\sqrt{\mu_0\epsilon_0}} = 2.998\times 10^8\ \mathrm{m/s}$

$m_e = 9.109\times 10^{-31}\ \mathrm{kg}$

$m_p = 1.673\times 10^{-27}\ \mathrm{kg}$

$m_n = 1.675\times 10^{-27}\ \mathrm{kg}$

## Trigonometric Identities

$\sin^2\theta + \cos^2\theta = 1$

$\sin(2\theta) = 2\sin(\theta)\cos(\theta)$

$\cos(2\theta) = \cos^2\theta - \sin^2\theta$

$\sin(\alpha\pm\beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$

$\cos(\alpha\pm\beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$

$\cos\alpha\cos\beta = \frac{1}{2}[\cos(\alpha-\beta)+\cos(\alpha+\beta)]$

$\sin\alpha\sin\beta = \frac{1}{2}[\cos(\alpha-\beta)-\cos(\alpha+\beta)]$

$\sin\alpha\cos\beta = \frac{1}{2}[\sin(\alpha+\beta)+\sin(\alpha-\beta)]$

$\sin\left(\theta+\frac{\pi}{2}\right) = \cos\theta$

$\cos\left(\theta+\frac{\pi}{2}\right) = -\sin\theta$

$\sec\theta := \frac{1}{\cos\theta}$

$\csc\theta := \frac{1}{\sin\theta}$

$\cot\theta := \frac{1}{\tan\theta}$

$\mathbf{F} = q\mathbf{E} + q\,\mathbf{v} \times \mathbf{B}$ | $\mathbf{F} = \frac{k\,q_1 q_2}{r^2}\,\hat{\mathbf{r}}$

$E = \frac{\sigma}{2\epsilon_0}$ | $E = \frac{\sigma}{\epsilon_0}$ | $E = 2\pi k\sigma\left(1 - \frac{x}{\sqrt{R^2+x^2}}\right)$

$\Phi_E = \int \mathbf{E} \cdot \mathrm{d}\mathbf{A}$ | $\Phi_B = \int \mathbf{B} \cdot \mathrm{d}\mathbf{A}$

$U = q\,V$ | $U = \frac{kq_1 q_2}{r}$ | $\Delta V = -\int \mathbf{E} \cdot \mathrm{d}\mathbf{s}$

$\mathbf{p} = q\mathbf{d}$ | $\boldsymbol{\tau} = \mathbf{p} \times \mathbf{E}$ | $U = -\mathbf{p} \cdot \mathbf{E}$

$\boldsymbol{\mu} = NI\mathbf{A}$ | $\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$ | $U = -\boldsymbol{\mu} \cdot \mathbf{B}$

$\mathbf{E} = \frac{1}{2\pi\epsilon_0}\frac{\mathbf{p}}{z^3}$ | $\mathbf{B} = \frac{\mu_0}{2\pi}\frac{\boldsymbol{\mu}}{z^3}$

$E = \frac{k\,q\,z}{(R^2+z^2)^{3/2}}$ | $B = \frac{\mu_0\,I\,R^2}{2(R^2+z^2)^{3/2}}$

$\mathbf{F} = I\,\mathbf{L} \times \mathbf{B}$ | $\frac{F_B}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$

$\mathbf{B} = \frac{\mu_0}{4\pi}\frac{q\,\mathbf{v}\times\hat{\mathbf{r}}}{r^2}$ | $\mathrm{d}\mathbf{B} = \frac{\mu_0}{4\pi}\frac{I\,\mathrm{d}\mathbf{s}\times\hat{\mathbf{r}}}{r^2}$ | $\mathbf{B} = \frac{\mu_0 I}{4\pi a}(\sin\theta_1 - \sin\theta_2)$

$B = \frac{\mu_0 I}{2\pi r}$ | $B = \frac{\mu_0 I\,r}{2\pi R^2}$ | $B = \mu_0 I n$

$r = \frac{mv_\perp}{|q|B}$ | $T = \frac{2\pi m}{|q|B}$ | $p = v_\parallel T$

$C = \frac{Q}{\Delta V}$ | $C = \frac{\kappa\,\epsilon_0 A}{d}$

$C = 2\pi\epsilon_0\,\frac{L}{\ln(b/a)}$ | $C = 4\pi\epsilon_0\,\frac{ab}{b-a}$

$L = \frac{N\Phi_B}{i}$ | $L = \mu_0 n^2 A\ell$ | $\mathcal{E}_L = -L\,\frac{\mathrm{di}}{\mathrm{dt}}$

$M = \frac{N_1\Phi_{B,2\to1}}{i_2} = \frac{N_2\Phi_{B,1\to2}}{i_1}$ | $\mathcal{E}_{M,1} = -M\,\frac{\mathrm{di}_2}{\mathrm{dt}}$ | $\Delta V_s = \Delta V_p\,\frac{N_s}{N_p}$

$U = \frac{1}{2}\frac{Q^2}{C}$ | $u = \frac{1}{2}\epsilon_0 E^2$

$U_B = \frac{1}{2}Li^2$ | $u_B = \frac{B^2}{2\mu_0}$

$\mathcal{E} = \frac{\mathrm{dW}}{\mathrm{dq}}$ | $P = \frac{\mathrm{dW}}{\mathrm{dt}}$ | $P = I\,\Delta V$

$R = \frac{\Delta V}{I}$ | $J = \frac{I}{A}$ | $\rho = \frac{E}{J} = \frac{1}{\sigma}$

$R = \frac{\rho L}{A}$ | $\rho - \rho_0 = \rho_0\alpha(T - T_0)$

$v_d = \frac{J}{ne}$ | $\Delta V_H = \frac{B\,I}{e\,n\,t}$

$q(t) = C\mathcal{E}(1 - e^{-t/\tau_C})$ | $i(t) = \frac{\mathcal{E}}{R}e^{-t/\tau_C}$ | $\Delta v_C(t) = \mathcal{E}(1 - e^{-t/\tau_C})$

$q(t) = Q_0 e^{-t/\tau_C}$ | $i(t) = I_0 e^{-t/\tau_C}$ | $\Delta v_C(t) = (\Delta V_0)e^{-t/\tau_C}$

$\tau_C = RC$ | $i(t) = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau_L})$ | $\Delta v_L(t) = \mathcal{E}e^{-t/\tau_L}$

$\tau_L = \frac{L}{R}$ | $i(t) = I_0 e^{-t/\tau_L}$ | $\Delta v_L(t) = (\Delta V_0)e^{-t/\tau_L}$

$X_L = \omega L$ | $X_C = \frac{1}{\omega C}$ | $\omega_0 = \frac{1}{\sqrt{LC}}$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ | $\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$ | $P_{\text{avg}} = I_{\text{rms}}\,\Delta V_{\text{rms}}\cos\phi$

$I_d = \epsilon_0\,\frac{\mathrm{d}\Phi_{\mathrm{E}}}{\mathrm{dt}}$ | $c = f\lambda$ | $c = \frac{E}{B}$

$\mathbf{S} = \frac{1}{\mu_0}\mathbf{E} \times \mathbf{B}$ | $P_{\text{rad}} = \frac{S}{c}$ | $P_{\text{rad}} = \frac{2S}{c}$