Values and Conversions

$g = 9.8$ N/kg $G = 6.67 \times 10^{-11}$ N·m²/kg² $\epsilon_0 = 8.85 \times 10^{-12}$ C²/N·m² $m_{\text{Earth}} = 5.97 \times 10^{24}$ kg

$e = 1.6 \times 10^{-19}$ C $k = 8.99 \times 10^9$ N·m²/C² $\mu_0 = 4\pi \times 10^{-7}$ N/A² $r_{\text{Earth}} = 6371$ km

$f_{\text{violet}} = 750$ THz $c = 3 \times 10^8$ m/s $f_{\text{red}} = 400$ THz   65 MPH = 29.1 m/s

Electron: $m_e = 9.11 \times 10^{-31}$ kg $q_e = -e$ 1 eV $= 1.6 \times 10^{-19}$ J

Proton: $m_p = 1.67 \times 10^{-27}$ kg $q_p = +e$ $h = 6.626 \times 10^{-34}$ J/Hz

Neutron: $m_n = 1.67 \times 10^{-27}$ kg $q_n = 0$ $v_{\text{sound}} \approx 343$ m/s

Review:

Math: SOH-CAH-TOA $Ax^2 + Bx + c = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

     Small-angle Approx $(\theta < 0.1$ rad$)$ $\cos\theta \approx 1$ $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

SI Prefixes: T$=10^{12}$ G$=10^9$ M$=10^6$ k$=10^3$ c$=10^{-2}$ m$=10^{-3}$ μ$=10^{-6}$ n$=10^{-9}$ p$=10^{-12}$

Phys1401: $F = ma$ $a = \Delta v/\Delta t$ $v_{\text{ave}} = \Delta s/\Delta t$ $\Delta x = v_i t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2a\Delta x$

     $F_g = mg$ $F_{\text{spring}} = -kx$ $PE_{\text{spring}} = \frac{1}{2}kx^2$ KE $= \frac{1}{2}mv^2$ $PE_g = mgh$ $F_B = \rho V_{\text{disp}}g$

Electrostatics: $q = Ne$

Gravity: $F_g = G\frac{mM}{r^2}$ $F_g = mg$ $g = G\frac{M}{r^2}$ $PE_G = -G\frac{mM}{r}$ $F_x = -\Delta PE/\Delta x$

Electric: $F_E = k\frac{qQ}{r^2}$ $\vec{F}_E = q\vec{E}$ $E = k\frac{Q}{r^2}$ $PE_E = k\frac{qQ}{r}$ $V = k\frac{Q}{r}$ $E_x = -\Delta V/\Delta x$

     $E = \frac{2k\lambda}{r} = \frac{\lambda}{2\pi\epsilon_0 r}$ $E = 2\pi k\sigma = \frac{\sigma}{2\epsilon_0}$ **or** $E = 4\pi k\sigma = \frac{\sigma}{\epsilon_0}$ $\Delta PE_E = q\Delta V$ $|\Delta V| = E_{\text{avg}}\ell$

Magnetism:

Magnetic: $\vec{F}_B = q\vec{v} \times \vec{B} = qv_\perp B$ $F_B = IL_\perp B$ $\tau_{\text{max}} = NBAI$

     $PE_B = -\mu B\cos\theta$ $B_{\text{wire}} = \frac{\mu I}{2\pi r}$ $B_{\text{coil}} = N\frac{\mu I}{2r}$ $B_{\text{sol}} = \mu_0 nI = \mu_0 NI/\ell$ $r = \frac{mv_\perp}{qB}$

Mag. Flux: $\Phi_B = NBA\cos\theta$ $\Phi_B = (\mu_0 N^2 A/\ell)I$ $\Phi_B = LI$

EMF: $\mathcal{E} = -\left(\frac{\Delta\Phi_B}{\Delta t}\right)$ $\mathcal{E} = vB\ell$ $\mathcal{E} = -L\frac{\Delta I}{\Delta t}$ $\mathcal{E}_{\text{max}} = NBA\omega$

DC and AC Circuits

Definitions: $I = \Delta Q/\Delta t$ $P = \Delta(\text{Energy})/\Delta t$ $P = IV = I^2 R$ $R = V/I$

Series: $I = I_1 = I_2 = \cdots$ $V_{\text{tot}} = V_1 + V_2 + \cdots$ $R_{\text{eq}} = R_1 + R_2 + \cdots$

Parallel: $I_{\text{tot}} = I_1 + I_2 + \cdots$ $V = V_1 = V_2 = \cdots$ $R_{\text{eq}} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \cdots\right)^{-1}$

Kirchoff: $\sum I_{\text{in}} = \sum I_{\text{out}}$ $\sum \Delta V = 0$ **Transformer:** $N_2/N_1 = V_2/V_1$

Physical RLC: $R = \frac{\rho L}{A}$ $C = \frac{\epsilon A}{d}$ $L = \mu N^2 A/\ell$

Voltage Laws: $V_R = IR$ $Q = CV_C$ $V_L = L(\Delta I/\Delta T)$

Energy: Energy $= \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}Q^2/C$ Energy $= \frac{1}{2}LI^2$

RC Circuit: $I = I_0 e^{-t/\tau}$ $V = V_0 e^{-t/\tau}$ $\tau = RC$ $V = V_f\left(1 - e^{-t/\tau}\right)$

AC Average-ish: $V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}}$ $I_{\text{RMS}} = \frac{I_{\text{max}}}{\sqrt{2}}$ $P_{\text{ave}} = \frac{P_{\text{max}}}{2}$

AC Impedances: $Z_R = R$ $X_C = 1/(2\pi f C)$ $X_L = 2\pi f L$ $V_{\text{RMS}} = I_{\text{RMS}}Z$

AC Power: $P_{R,\text{ave}} = I_{\text{RMS}}V_{\text{RMS}}$ $P_{C,\text{ave}} = 0$ $P_{L,\text{ave}} = 0$

Series Impedance: $X = X_L - X_C$ $Z_{\text{eq}} = \sqrt{R^2 + X^2}$ **Resonance:** $f_R = 1/\left(2\pi\sqrt{LC}\right)$

AC Waveform: $V(t) = V_{\text{max}}\sin(2\pi f t)$

Phys 1402: General Physics II
Summer 2017 — Equation Sheet

Oscillations/Waves:

Fundamental: $v = f\lambda = \dfrac{\lambda}{T}$ $f = 1/T$ $\omega = 2\pi f$ $x(t) = x_{\max}\cos(2\pi f t + \phi)$

Specific Cases: $f = \dfrac{1}{2\pi}\sqrt{\dfrac{k}{m}}$ $f = \dfrac{1}{2\pi}\sqrt{\dfrac{g}{L}}$ $v = \sqrt{\dfrac{F_T}{\mu}}$

Intensity: $I = \dfrac{\text{power}}{\text{area}} = \dfrac{P}{A}$ $I_{\text{point source}} = \dfrac{P}{4\pi R^2}$ $I \propto (\text{Amplitude})^2$

Intensity Level: $\beta = 10\log\left(\dfrac{I}{I_0}\right)$ $I = I_0 10^{\beta/10}$

Phase Shifts: $\Delta\ell = m\lambda$ $\Delta t = mT$ (m = integer for constructive)

Standing Waves: Similar Ends: $2L = m\lambda$ $f = if_0, i = $ integer
                      Different Ends: $4L = i\lambda$ $f = if_0, i = $ odd

Beat Frequency: $f_{\text{beat}} = |\Delta f| = |f_2 - f_1|$ **Diffraction Grating:** $m\lambda = d\sin\theta$ $\tan\theta = \dfrac{y}{L}$

Doppler: $\dfrac{\Delta f}{f} = \dfrac{v_{\text{rel}}}{v_{\text{wave}}}$ ($\times 2$ if reflected)   **Polarizer:** $I = I_0 \cos^2\theta$

Light and Optics

Nature of Light: $E_\gamma = hf$ $v_n = c/n$ $\lambda_n = \lambda_0/n$

Reflection: $\theta_i = \theta_r$ **Refraction:** $n_1\sin\theta_1 = n_2\sin\theta_2$

Brewster's Angle: $\tan\theta_p = n_2/n_1$ **Tot. Int. Refl.:** $\sin\theta_2 \geq 1$ (reflected)

Lenses/Mirrors: $\dfrac{1}{p} + \dfrac{1}{q} = \dfrac{1}{f}$ **Linear Mag.:** $M = \dfrac{h'}{h} = -\dfrac{q}{p}$

Configurations: **Projector:** Converging   Real Object outside focal point   Real Image
                      Magnifier: Converging   Real Object inside focal point   Virtual Image
                      Reducer: Diverging   Real Object anywhere   Virtual Image

Angular Size: $\theta = \tan^{-1}\left(\dfrac{h'}{q}\right) \approx \dfrac{h'}{q}$ **Angular Mag.:** $m = \dfrac{\theta_{\text{with}}}{\theta_{\text{without}}}$

Optical Instruments: Angular mag. (m) of the instrument is the important magnification.

Mag. Glass: $\theta_{\text{without}} = h/d_{\text{np}}$ (Assume $d_{\text{np}} = 25$ cm) $\theta_{\text{with}} = h/f$ (relaxed eyes)

$m = \dfrac{25\text{ cm}}{f}$ (relaxed eyes) $m = \dfrac{25\text{ cm}}{f} + 1$ (maximum mag)

Microscope: $m = m_{\text{eyepiece}}M_{\text{objective}} = -\left(\dfrac{25\text{ cm}}{f_e}\right)\left(\dfrac{L}{f_o}\right)$

Telescope: $h' = \theta_{\text{object}}f_o$ $\theta_{\text{without}} = h'/f_o$ $\theta_{\text{with}} = h'/f_e$ $m = \dfrac{f_o}{f_e}$