Phys 1402: General Physics II
Fall 2017 — Equation Sheet

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	$q_e = -e$	$1\text{ eV} = 1.6 \times 10^{-19}$ 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 $\qquad Ax^2 + Bx + c = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

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

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

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

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

$F_G = G\frac{mM}{r^2} \qquad F_g = mg \qquad PE_G = -G\frac{mM}{r} \qquad F_x = -\Delta\text{PE}/\Delta x$

Electrostatics: $Q = q_1 + q_2 + \cdots \qquad Q = (N_p - N_e)e \qquad F_E = k\frac{qQ}{r^2} \qquad \vec{F}_E = q\vec{E} \qquad E = k\frac{Q}{r^2}$

$E = \frac{2k\lambda}{r} = \frac{\lambda}{2\pi\epsilon_0 r} \qquad E = 4\pi k\sigma = \frac{\sigma}{\epsilon_0} \qquad \Phi_E = E_{\perp,\text{avg}}A = 4\pi kQ = Q/\epsilon_0$

$E_x = -\frac{\Delta V}{\Delta x} \qquad V = k\frac{Q}{r} \qquad |\Delta V| = E_{\text{avg}}\ell \qquad \text{PE}_E = k\frac{qQ}{r} \qquad \Delta\text{PE}_\text{E} = q\Delta V$

DC Circuits: $I = \Delta Q/\Delta t \qquad P = \Delta(\text{Energy})/\Delta t \qquad P = IV = I^2R \qquad V = IR \qquad R = \frac{\rho L}{A}$

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

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

Kirchoff: $\sum I_{\text{in}} = \sum I_{\text{out}} \qquad \sum \Delta V = 0 \qquad$ **Drift:** $v_d = I/(neA)$

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

Magnetism:

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

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

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

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

AC Circuits: $V(t) = V_{\text{max}}\sin(2\pi ft) \qquad V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}} \qquad I_{\text{RMS}} = \frac{I_{\text{max}}}{\sqrt{2}} \qquad V_{\text{RMS}} = I_{\text{RMS}}Z \qquad P_{R,\text{ave}} = \frac{P_{\text{max}}}{2}$

$C = \frac{\epsilon A}{d} \qquad Q = CV_C \qquad X_C = 1/(2\pi fC) \qquad \text{Energy} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}Q^2/C$

$L = \mu N^2 A/\ell \qquad V_L = L(\Delta I/\Delta T) \qquad X_L = 2\pi fL \qquad \text{Energy} = \frac{1}{2}LI^2$

Series Impedance: $X = X_L - X_C \qquad Z_{\text{eq}} = \sqrt{R^2 + X^2} \qquad$ **Transformer:** $N_2/N_1 = V_2/V_1$

Resonance: $X_L = X_C \qquad f_R = 1/(2\pi\sqrt{LC})$

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Oscillations/Waves:

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

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

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

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

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

Standing Waves: Similar Ends: $2L = m\lambda$ $f = if_0, i = \text{integer}$

Different Ends: $4L = i\lambda$ $f = if_0, i = \text{odd}$

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

Doppler: $\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}}$ (× 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: $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$ **Linear Mag.:** $M = \frac{h'}{h} = -\frac{q}{p}$

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

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

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

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

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

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