

**Phys 1402: General Physics II**  
**Summer 2020**

**Equation Sheet**

(Tear off Equation Sheets one at a time.)

**Values and Conversions**

$g = 9.8 \text{ N/kg}$	$G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$	$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$	$m_{\text{Earth}} = 5.97 \times 10^{24} \text{ kg}$
$e = 1.6 \times 10^{-19} \text{ C}$	$k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$	$\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$	$r_{\text{Earth}} = 6371 \text{ km}$
$f_{\text{violet}} = 750 \text{ THz}$	$c = 3 \times 10^8 \text{ m/s}$	$f_{\text{red}} = 400 \text{ THz}$	$65 \text{ MPH} = 29.1 \text{ m/s}$
<b>Electron:</b>	$m_e = 9.11 \times 10^{-31} \text{ kg}$	$q_e = -e$	$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$
<b>Proton:</b>	$m_p = 1.67 \times 10^{-27} \text{ kg}$	$q_p = +e$	$h = 6.626 \times 10^{-34} \text{ J/Hz}$
<b>Neutron:</b>	$m_n = 1.67 \times 10^{-27} \text{ kg}$	$q_n = 0$	$v_{\text{sound}} \approx 343 \text{ m/s}$

**Review:**

<b>Math:</b>	SOH-CAH-TOA	$Ax^2 + Bx + c = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$
Small-angle Approx	$(\theta < 0.1 \text{ rad})$	$\cos \theta \approx 1 \quad \sin \theta \approx \tan \theta \approx \theta \text{ (in radians)}$
<b>SI Prefixes:</b>	$T=10^{12} \text{ G}=10^9 \text{ M}=10^6 \text{ k}=10^3$	$c=10^{-2} \text{ m}=10^{-3} \mu=10^{-6} \text{ n}=10^{-9} \text{ p}=10^{-12}$
<b>Phys 1401:</b>	$F = ma \quad a = \Delta v/\Delta t \quad v_{\text{ave}} = \Delta s/\Delta t$	$\Delta x = v_i t + \frac{1}{2}at^2 \quad v^2 = v_0^2 + 2a\Delta x$
	$F_{\text{spring}} = -kx \quad PE_{\text{spring}} = \frac{1}{2}kx^2 \quad KE = \frac{1}{2}mv^2 \quad PE_g = mgh \quad F_B = \rho V_{\text{disp}} g$	
	$F_G = G \frac{mM}{r^2} \quad F_g = mg \quad PE_G = -G \frac{mM}{r}$	$F_x = -\Delta PE/\Delta x$

<b>Electrostatics:</b>	$Q = q_1 + q_2 + \dots \quad Q = (N_p - N_e)e$	$F_E = k \frac{qQ}{r^2} \quad \vec{F}_E = q \vec{E} \quad E = k \frac{Q}{r^2}$
$E_{\text{line}} = \frac{2k\lambda}{r} = \frac{\lambda}{2\pi\epsilon_0 r} \quad E_{\text{surface}} = 4\pi k\sigma = \frac{\sigma}{\epsilon_0}$		<b>Gauss's Law:</b> $\Phi_E = E_{\perp, \text{avg}} A = 4\pi kQ = Q/\epsilon_0$
$E_x = -\frac{\Delta V}{\Delta x} \quad  \Delta V  = E_{\text{avg}} \ell$	$V = k \frac{Q}{r}$	$PE_E = k \frac{qQ}{r} \quad \Delta PE_E = q \Delta V$
<b>DC Circuits:</b>	$I = \Delta Q/\Delta t \quad P = \Delta(\text{Energy})/\Delta t \quad P = IV = I^2 R \quad V = IR \quad R = \frac{\rho L}{A}$	
<b>Series:</b>	$I = I_1 = I_2 = \dots \quad V_{\text{tot}} = V_1 + V_2 + \dots \quad R_{\text{eq}} = R_1 + R_2 + \dots$	
<b>Parallel:</b>	$I_{\text{tot}} = I_1 + I_2 + \dots \quad V = V_1 = V_2 = \dots \quad R_{\text{eq}} = \left( \frac{1}{R_1} + \frac{1}{R_2} + \dots \right)^{-1}$	
<b>Kirchoff:</b>	$\sum I_{\text{in}} = \sum I_{\text{out}} \quad \sum \Delta V = 0$	<b>Drift:</b> $v_d = I/(neA)$
<b>Capacitor:</b>	$C = \frac{\epsilon A}{d} \quad Q = CV_C \quad \text{Energy} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}Q^2/C$	
<b>RC Circuit:</b>	$I = I_0 e^{-t/\tau} \quad V_{\text{draining}} = V_0 e^{-t/\tau} \quad \tau = RC \quad V_{\text{charging}} = V_f(1 - e^{-t/\tau})$	

**Magnetism:**

$\vec{F}_B = q\vec{v} \times \vec{B} = qv_{\perp}B$	$F_B = IL_{\perp}B \quad \tau_{\max} = NBAI$
$PE_B = -\mu B \cos \theta \quad B_{\text{wire}} = \frac{\mu I}{2\pi r} \quad B_{\text{coil}} = N \frac{\mu I}{2r} \quad B_{\text{sol}} = \mu_0 NI/\ell \quad r = \frac{mv_{\perp}}{qB}$	
<b>Mag. Flux:</b> $\Phi_B = NBA \cos \theta \quad \Phi_B = (\mu_0 N^2 A/\ell)I \quad \Phi_B = LI$	
<b>EMF:</b> $\mathcal{E} = -\left(\frac{\Delta \Phi_B}{\Delta t}\right) \quad \mathcal{E} = vB\ell \quad \mathcal{E} = -L \frac{\Delta I}{\Delta t} \quad \mathcal{E}_{\max} = NBA\omega$	
<b>AC Circuits:</b> $V(t) = V_{\max} \sin(2\pi ft) \quad V_{\text{RMS}} = \frac{V_{\max}}{\sqrt{2}} \quad I_{\text{RMS}} = \frac{I_{\max}}{\sqrt{2}} \quad V_{\text{RMS}} = I_{\text{RMS}} Z \quad P_{R, \text{avg}} = I_{\text{rms}}^2 R$	
$C = \frac{\epsilon A}{d} \quad Q = CV_C \quad X_C = 1/(2\pi fC) \quad \text{Energy} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}Q^2/C$	
$L = \mu N^2 A/\ell \quad V_L = L(\Delta I/\Delta T) \quad X_L = 2\pi fL \quad \text{Energy} = \frac{1}{2}LI^2$	
<b>Series Impedance:</b> $X = X_L - X_C \quad Z_{\text{eq}} = \sqrt{R^2 + X^2} \quad \text{Transformer: } N_2/N_1 = V_2/V_1$	
<b>Resonance:</b> $X_L = X_C \quad f_R = 1/(2\pi\sqrt{LC}) \quad \omega = 2\pi f$	

### Oscillations/Waves:

<b>Fundamental:</b>	$v = f\lambda = \frac{\lambda}{T}$	$f = 1/T$	$\omega = 2\pi f$	$x(t) = x_{\max} \cos(2\pi ft + \phi)$
<b>Specific Cases:</b>	$f = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$	$f = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$		$v = \sqrt{\frac{F_T}{\mu}}$
<b>Intensity:</b>	$I = \frac{\text{power}}{\text{area}} = \frac{P}{A}$	$I_{\text{point source}} = \frac{P}{4\pi R^2}$		$I \propto (\text{Amplitude})^2$
<b>Intensity Level:</b>	$\beta = 10 \log \left( \frac{I}{I_0} \right)$	$I = I_0 10^{\beta/10}$		
<b>Selected dB Values:</b>	+3 dB $\leftrightarrow$ 2 $\times$	+5 dB $\leftrightarrow$ 3 $\times$	+7 dB $\leftrightarrow$ 5 $\times$	+10 dB $\leftrightarrow$ 10 $\times$
<b>Phase Shifts:</b>	$\Delta\ell = m\lambda$	$\Delta t = mT$		( $m$ = integer for constructive)
<b>Standing Waves:</b>	Similar Ends: Different Ends:	$2L = m\lambda$ $4L = m\lambda$	$f = mf_0, m = \text{integer}$ $f = mf_0, m = \text{odd integer}$	
<b>Beat Frequency:</b>	$f_{\text{beat}} =  \Delta f  =  f_2 - f_1 $		<b>Diffraction Grating:</b>	$m\lambda = d \sin \theta$
<b>Doppler:</b>	$\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}} \quad (\times 2 \text{ if reflected})$		<b>Polarizer:</b>	$I = I_0 \cos^2 \theta$

### Light and Optics

<b>Nature of Light:</b>	$E_\gamma = hf$	$v_n = c/n$	$\lambda_n = \lambda_0/n$
<b>Reflection:</b>	$\theta_i = \theta_r$		<b>Refraction:</b> $n_1 \sin \theta_1 = n_2 \sin \theta_2$
<b>Brewster's Angle:</b>	$\tan \theta_p = n_2/n_1$		<b>Tot. Int. Refl.:</b> $\sin \theta_2 \geq 1 \quad (\text{reflected})$
<b>Lenses/Mirrors:</b>	$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$		<b>Linear Mag.:</b> $M = \frac{h'}{h} = -\frac{q}{p}$
<b>Configurations:</b>	<b>Projector:</b> Converging <b>Magnifier:</b> Converging <b>Reducer:</b> Diverging	Real Object outside focal point Real Object inside focal point Real Object anywhere	Real Image Virtual Image Virtual Image
<b>Angular Size:</b>	$\theta = \tan^{-1} \left( \frac{h'}{q} \right) \approx \frac{h'}{q}$	<b>Angular Mag.:</b>	$m = \frac{\theta_{\text{with}}}{\theta_{\text{without}}}$
<b>Optical Instruments:</b>	Angular mag. ( $m$ ) of the instrument is the important magnification.		
<b>Mag. Glass:</b>	$\theta_{\text{without}} = h/d_{\text{np}}$ (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)	
<b>Microscope:</b>	$m = m_{\text{eyepiece}} M_{\text{objective}} = -\left(\frac{25 \text{ cm}}{f_e}\right)\left(\frac{L}{f_o}\right)$		
<b>Telescope:</b>	$h' = \theta_{\text{object}} f_o$	$\theta_{\text{without}} = h'/f_o$	$\theta_{\text{with}} = h'/f_e$
			$m = \frac{f_o}{f_e}$