

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:

**Math:** SOH-CAH-TOA

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

Small-angle Approx ( $\theta < 0.1 \text{ rad}$ )

$$\cos \theta \approx 1 \quad \sin \theta \approx \tan \theta \approx \theta \text{ (in radians)}$$

**SI Prefixes:** T= $10^{12}$  G= $10^9$  M= $10^6$  k= $10^3$

$$c=10^{-2} \text{ m}=10^{-3} \mu=10^{-6} \text{ n}=10^{-9} \text{ p}=10^{-12}$$

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

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

Forces, Fields, and Energies:

**Gravity:**  $\vec{F}_G = m_0 \vec{g}$   $g = G \frac{m_1}{r^2}$   $PE_G = -G \frac{m_0 m_1}{r}$   $F_x = -\Delta PE / \Delta x$

**Electric:**  $\vec{F}_E = q_0 \vec{E}$   $E_x = -\Delta V / \Delta x$   $|\Delta V| = E_{\text{avg}} \ell$   $\Delta PE_E = q_0 \Delta V$

$$E = k \frac{|q_1|}{r^2} \quad PE_E = k \frac{q_0 q_1}{r} \quad V = k \frac{q_1}{r} \quad E = \frac{2k\lambda}{r} = \frac{\lambda}{2\pi\epsilon_0 r} \quad E = 2\pi k\sigma = \frac{\sigma}{2\epsilon_0} \text{ or } E = 4\pi k\sigma = \frac{\sigma}{\epsilon_0}$$

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

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

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

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

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

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

**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:**  $f_R = 1 / (2\pi\sqrt{LC})$

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

Oscillations/Waves:

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

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

**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:**  $\Delta\ell = m\lambda$        $\Delta t = mT$       ( $m = \text{integer for constructive}$ )

**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:**  $\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}} (\times 2 \text{ if reflected})$       **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:**  $h' = \theta_{\text{object}} f_o$        $\theta_{\text{without}} = h'/f_o$        $\theta_{\text{with}} = h'/f_e$        $m = \frac{f_o}{f_e}$