

Values and Conversions

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

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

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

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

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

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

$$E_x = -\frac{\Delta V}{\Delta x} \quad V = k \frac{Q}{r} \quad |\Delta V| = E_{\text{avg}} \ell \quad PE_E = k \frac{qQ}{r} \quad \Delta PE_E = q\Delta V$$

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

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

Capacitor: $C = \frac{\epsilon A}{d}$ $Q = CV_C$ $\text{Energy} = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} Q^2 / C$

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

Magnetism:

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

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

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

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

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

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

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

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

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

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

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

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