

Fall 2016

Values and Conversions

$g = 9.8 \text{ N/kg}$ $G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$ $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$ $r_{\text{Earth}} = 6371 \text{ km}$
 $e = 1.6 \times 10^{-19} \text{ C}$ $k = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$ $\mu_0 = 4\pi \times 10^{-7} \text{ N/A}^2$ $m_{\text{earth}} = 5.97 \times 10^{24} \text{ kg}$
 $f_{\text{violet}} = 750 \text{ THz}$ $c = 3 \times 10^8 \text{ m/s}$ $f_{\text{red}} = 400 \text{ THz}$ $65 \text{ MPH} = 29.1 \text{ m/s}$
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: $m_n = 1.67 \times 10^{-27} \text{ kg}$ $q_n = 0$ $v_{\text{sound}} \approx 340 \text{ m/s}$
Math: SOH-CAH-TOA $A = \pi r^2$ $C = 2\pi r$ $V = \frac{4}{3}\pi r^3$ $A = 4\pi r^2$
 Small-angle Approx ($\theta < 0.1 \text{ rad}$) $\cos \theta \approx 1$ $\sin \theta \approx \tan \theta \approx \theta$ (in radians)

$f(x) \approx f_0 + \frac{\partial f}{\partial x} \Delta x$ $(1 + \delta)^n \approx (1 + n\delta)$ $\sqrt{1 + \delta} \approx 1 + \frac{\delta}{2}$ $Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$
Vectors: $x = r \cos \theta$ $y = r \sin \theta$ **SI Prefixes:** $k=10^3$ $M=10^6$ $G=10^9$ $T=10^{12}$
 $r = \sqrt{x^2 + y^2}$ $\theta = \tan^{-1}\left(\frac{y}{x}\right) \underset{\text{maybe}}{+180^\circ}$ $c=10^{-2}$ $m=10^{-3}$ $\mu=10^{-6}$ $n=10^{-9}$ $p=10^{-12}$

Phys2425: $F = ma$ $\vec{v} = d\vec{x}/dt$ $\vec{a} = d\vec{v}/dt$ $\Delta x = v_i t + \frac{1}{2}at^2$ $v^2 = v_0^2 + 2a\Delta x$
 $K = \frac{1}{2}mv^2$ $F_{\text{spring}} = -kx$ $U_{\text{spring}} = \frac{1}{2}kx^2$ $U_g = mgy$ $F_g = mg$ $F_B = \rho V_{\text{disp}}g$

Forces, Fields, and Energies:

Gravity: $\vec{F}_g = m_0\vec{g}$ $g = G \frac{m_1}{r^2}$ $U_G = -G \frac{m_0 m_1}{r}$ $F_x = -dU/dx$
Electric: $\vec{F}_E = q_0\vec{E}$ $E_x = -dV/dx$ $|\Delta V| = E_{\text{avg}}\ell$ $\Delta U_E = q_0\Delta V$ $\Phi_E = E_{\perp}A = Q_{\text{enc}}/\epsilon_0$
 $E = k \frac{|q_1|}{r^2}$ $U_E = q_0V$ $V = k \frac{q_1}{r}$ $E = \frac{2k\lambda}{r} = \frac{\lambda}{2\pi\epsilon_0 r}$ $E = 2\pi k\sigma = \frac{\sigma}{2\epsilon_0}$ or $E = 4\pi k\sigma = \frac{\sigma}{\epsilon_0}$
Magnetic: $\vec{F}_B = q\vec{v} \times \vec{B} = qv_{\perp}B$ $F_B = IL_{\perp}B$ $\tau = NBAI \sin \theta$ $\tau_{\text{max}} = NBAI$ $r = \frac{mv_{\perp}}{qB}$
 $U_B = mB \cos \theta$ $B_{\text{wire}} = \frac{\mu I}{2\pi r}$ $B_{\text{coil}} = N \frac{\mu I}{2r}$ $B_{\text{sol}} = \mu_0 nI = \mu_0 NI/\ell$ $B_{\parallel}\ell = \mu_0 I_{\text{enc}}$
Mag Flux: $\Phi_B = NBA \cos \theta$ $\Phi_B = (\mu_0 N^2 A/\ell)I$ $\Phi_B = LI$
EMF: $\mathcal{E} = -\frac{d\Phi_B}{dt}$ $\mathcal{E} = vB\ell$ $\mathcal{E} = -L \frac{dI}{dt}$ $\mathcal{E}_{\text{max}} = NBA\omega$

DC and AC Circuits

Definitions: $I = dQ/dt$ $P = d(\text{Energy})/dt$ $P = IV$ $R = \frac{V}{I}$
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:** $N_2/N_1 = V_2/V_1$
RLC Values: $R = \rho\ell/A$ $C = \kappa\epsilon_0 A/d$ $L = \mu_0 N^2 A/\ell$
Voltage Laws: $V_R = IR$ $Q = CV_C$ $V_L = L(dI/dT)$
Energies: $\text{Energy} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}Q^2/C$ $\text{Energy} = \frac{1}{2}LI^2$
RC: $I = I_0 e^{-t/\tau}$ $V = V_0 e^{-t/\tau}$ $\tau = RC$ $V = V_f(1 - e^{-t/\tau})$
AC Average-ish: $V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}}$ $I_{\text{RMS}} = \frac{I_{\text{max}}}{\sqrt{2}}$ $P_{\text{ave}} = \frac{P_{\text{max}}}{2}$ $V_{\text{RMS}} = I_{\text{RMS}}Z$
AC Impedances: $Z_R = R$ $X_C = 1/(2\pi fC)$ $X_L = 2\pi fL$
AC Power: $P_{R,\text{ave}} = I_{\text{RMS}}V_{\text{RMS}}$ $P_{C,\text{ave}} = 0$ $P_{L,\text{ave}} = 0$
Series Impedance: $X = X_L - X_C$ $Z_{\text{eq}} = \sqrt{R^2 + X^2}$ $f_R = \frac{1}{2\pi\sqrt{LC}}$ $V = IZ$
AC Waveform: $V(t) = V_{\text{max}} \sin(2\pi ft)$

Oscillations/Waves:

Fundamental: $v = f\lambda = \frac{\lambda}{T}$ $f = 1/T$ $\omega = 2\pi f$ $k = \frac{2\pi}{\lambda}$
 $x = x_{\max} \sin(kx - \omega t + \phi_0)$

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

Sound Level: $\beta = 10 \log\left(\frac{I}{I_0}\right)$ $I = I_0 10^{\beta/10}$ **Doppler:** $\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}} (\times 2 \text{ if reflected})$

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

Standing Waves: Similar Ends: $2L = i\lambda$ $f = if_0, i = \text{integer}$
 Different Ends: $4L = i\lambda$ $f = if_0, i = \text{odd}$
 $2L = (m + \frac{1}{2})\lambda$ ($m = \text{integer; equivalent to above}$)

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

Rayleigh criterion: $\theta_{\min} = 1.22 \frac{\lambda}{D}$ **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.:** $\sin \theta_2 = 1$ (makes θ_1 critical angle)

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

Optical Instruments: If magnification matters, it is the angular mag. (m) of the instrument.

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

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