

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

Electrostatics:	$Q = \sum q_i$	$Q = \int \lambda d\ell = \lambda_{\text{avg}} \ell$	$Q = \int \sigma dA = \sigma_{\text{avg}} A$	$Q = \int \rho dV = \rho_{\text{avg}} V$
$F_E = k \frac{qQ}{r^2}$	$\vec{F}_E = q\vec{E}$	$E = k \frac{Q}{r^2}$	$E = \frac{2k\lambda}{r} = \frac{\lambda}{2\pi\epsilon_0 r}$	$E = 2\pi k\sigma = \frac{\sigma}{2\epsilon_0}$ or $E = 4\pi k\sigma = \frac{\sigma}{\epsilon_0}$
$E_x = -\frac{dV}{dx}$	$ \Delta V = \vec{E}_{\text{avg}} \cdot \vec{\ell}$	$V = k \frac{Q}{r}$	$\Delta U_E = q\Delta V$	
$\Phi_E = 4\pi k Q_{\text{enc}} = Q_{\text{enc}}/\epsilon_0$		$E = \Phi_E/A$		
DC Circuits:	$I = dQ/dt$	$P = d(\text{Energy})/dt$	$P = IV$	$V = IR$ $R = \rho \ell / A$
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: $v_d = I/(neA)$
RC Circuit:	$I = I_0 e^{-t/\tau}$	$V = V_0 e^{-t/\tau}$	$\tau = RC$	$V = V_f(1 - e^{-t/\tau})$

Magnetism:

$\vec{F}_B = q\vec{v} \times \vec{B} = qv_{\perp}B$	$F_B = IL_{\perp}B$	$\tau = NBAI \sin \theta$	$\tau_{\text{max}} = NBAI$	$r = \frac{mv_{\perp}}{qB}$
$U_B = -\mu B \cos \theta$	$B_{\text{wire}} = \frac{\mu I}{2\pi r}$	$B_{\text{coil}} = N \frac{\mu I}{2r}$	$B_{\text{sol}} = \mu_0 NI / \ell$	$B_{\parallel} \ell = \mu_0 I_{\text{enc}}$
Mag Flux:	$\Phi_B = \iint \vec{B} \cdot d\vec{A} = NBA \cos \theta$	$\Phi_B = (\mu_0 N^2 A / \ell) I$	$\Phi_B = LI$	
EMF:	$\mathcal{E} = -\frac{d\Phi_B}{dt}$	$\mathcal{E} = vB\ell$	$\mathcal{E} = -L \frac{dI}{dt}$	$\mathcal{E}_{\text{max}} = NBA\omega$
AC Circuits:	$V(t) = V_{\text{max}} \sin(2\pi ft)$	$V_{\text{RMS}} = \frac{V_{\text{max}}}{\sqrt{2}}$	$I_{\text{RMS}} = \frac{I_{\text{max}}}{\sqrt{2}}$	$V_{\text{RMS}} = I_{\text{RMS}} Z$ $P_{R,\text{avg}} = I_{\text{rms}}^2 R$
$C = \kappa \epsilon_0 A / d$	$Q = CV_C$	$X_C = 1/(2\pi fC)$	$\text{Energy} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}Q^2/C$	
$L = \mu_0 N^2 A / \ell$	$V_L = L(dI/dT)$	$X_L = 2\pi fL$	$\text{Energy} = \frac{1}{2}LI^2$	
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:	$X_L = X_C$	$f_R = \frac{1}{2\pi\sqrt{LC}}$	$\omega = 2\pi f$	

Oscillations/Waves:

Fundamental:	$v = f\lambda = \frac{\lambda}{T}$	$f = 1/T$	$\omega = 2\pi f$	$k = \frac{2\pi}{\lambda}$
	$x = x_{\max} \sin(kx - \omega t + \phi_0)$			
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:	$\frac{\Delta f}{f} = \frac{v_{\text{rel}}}{v_{\text{wave}}} (\times 2 \text{ if reflected})$
Intensity:	$P = IA$	Point Source:	$I = \frac{P}{4\pi r^2}$	
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:	$4L = i\lambda$	$f = if_0, i = \text{odd}$	
		$2L = \left(m + \frac{1}{2}\right)\lambda$	$(m = \text{integer; equivalent to above})$	
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.:	$m = \theta_{\text{with}}/\theta_{\text{without}}$
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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:	$h' = -\theta_{\text{object}} f_o$	$\theta_{\text{without}} = -h'/f_o$	$\theta_{\text{with}} = h'/f_e$	$m = -\frac{f_o}{f_e}$
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