Phys 2426: University Physics II — Equation Sheet
Fall 2015

Values and Conversions

$g = 9.8$ N/kg $\quad G = 6.67 \times 10^{-11}$ N·m²/kg² $\quad \epsilon_0 = 8.85 \times 10^{-12}$ C²/N·m² $\quad r_{\text{Earth}} = 6371$ km

$e = 1.6 \times 10^{-19}$ C $\quad k = 8.99 \times 10^9$ N·m²/C² $\quad \mu_0 = 4\pi \times 10^{-7}$ N/A² $\quad m_{\text{earth}} = 5.97 \times 10^{24}$ kg

$f_{\text{violet}} = 750$ THz $\quad c = 3 \times 10^8$ m/s $\quad f_{\text{red}} = 400$ THz $\quad 65$ MPH $= 29.1$ m/s

Electron: $m_e = 9.11 \times 10^{-31}$ kg $\quad q_e = -e \quad 1$ eV $= 1.6 \times 10^{-19}$ J

Proton: $m_p = 1.67 \times 10^{-27}$ kg $\quad q_p = +e \quad h = 6.626 \times 10^{-34}$ J/Hz

Neutron: $m_n = 1.67 \times 10^{-27}$ kg $\quad q_n = 0 \quad v_{\text{sound}} \approx 340$ m/s

Math: SOH-CAH-TOA $\quad A = \pi r^2 \quad C = 2\pi r \quad V = \frac{4}{3}\pi r^3 \quad A = 4\pi r^2$

Small-angle Approx $(\theta < 0.1 \text{ rad}) \quad \cos\theta \approx 1 \quad \sin\theta \approx \tan\theta \approx \theta$ (in radians)

$f(x) \approx f_0 + \frac{\partial f}{\partial x}\Delta x \quad (1+\delta)^n \approx (1+n\delta) \quad \sqrt{1+\delta} \approx 1 + \frac{\delta}{2} \quad Ax^2 + Bx + C = 0 \rightarrow x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

Components: $x = r\cos\theta \quad y = r\sin\theta$ $\quad$ **SI Prefixes:** k=10^3 M=10^6 G=10^9 T=10^{12}

$r = \sqrt{x^2 + y^2} \quad \theta = \tan^{-1}\left(\frac{y}{x}\right) \underbrace{+180°}_{\text{maybe}}$ $\quad$ c=10^{-2} m=10^{-3} μ=10^{-6} n=10^{-9} p=10^{-12}

Phys2425: $F = ma \quad \vec{v} = d\vec{x}/dt \quad \vec{a} = d\vec{v}/dt \quad \Delta x = v_i t + \frac{1}{2}at^2 \quad v^2 = v_0^2 + 2a\Delta x$

$K = \frac{1}{2}mv^2 \quad F_{\text{spring}} = -kx \quad U_{\text{spring}} = \frac{1}{2}kx^2 \quad U_G = mgy \quad F_G = mg \quad F_B = \rho V_{\text{disp}} g$

Forces, Fields, and Energies:

Gravity: $\vec{F}_G = m_0\vec{g} \quad g = G\frac{m_1}{r^2} \quad U_G = -G\frac{m_0 m_1}{r} \quad F_x = -dU/dx$

Electric: $\vec{F}_E = q_0\vec{E} \quad E_x = -dV/dx \quad |\Delta V| = E_{\text{avg}}\ell \quad \Delta U_E = q_0\Delta V \quad \Phi_E = E_\perp A = Q_{\text{enc}}/\epsilon_0$

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

Magnetic: $\vec{F}_B = q\vec{v} \times \vec{B} = qv_\perp B \quad F_B = IL_\perp B \quad \tau = NBAI\sin\theta \quad \tau_{\max} = NBAI \quad r = \frac{mv_\perp}{qB}$

$U_B = mB\cos\theta \quad B_{\text{wire}} = \frac{\mu I}{2\pi r} \quad B_{\text{coil}} = N\frac{\mu I}{2r} \quad B_{\text{sol}} = \mu_0 nI = \mu_0 NI/\ell \quad B_\parallel \ell = \mu_0 I_{\text{enc}}$

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

EMF: $\mathcal{E} = -\frac{d\Phi_B}{dt} \quad \mathcal{E} = vB\ell \quad \mathcal{E} = -L\frac{dI}{dt} \quad \mathcal{E}_{\max} = NBA\omega$

DC and AC Circuits

Definitions: $I = dQ/dt \quad P = d(\text{Energy})/dt \quad P = IV \quad R = \frac{V}{I}$

Series: $I = I_1 = I_2 = \cdots \quad V_{\text{tot}} = V_1 + V_2 + \cdots \quad R_{\text{eq}} = R_1 + R_2 + \cdots$

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

Kirchoff: $\sum I_{\text{in}} = \sum I_{\text{out}} \quad \sum\Delta V = 0$ $\quad$ **Transformer:** $N_2/N_1 = V_2/V_1$

RLC Values: $R = \rho\ell/A \quad C = \kappa\epsilon_0 A/d \quad L = \mu_0 N^2 A/\ell$

Voltage Laws: $V_R = IR \quad Q = CV_C \quad V_L = L(dI/dT)$

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

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

AC Average-ish: $V_{\text{RMS}} = \frac{V_{\max}}{\sqrt{2}} \quad I_{\text{RMS}} = \frac{I_{\max}}{\sqrt{2}} \quad P_{\text{ave}} = \frac{P_{\max}}{2} \quad V_{\text{RMS}} = I_{\text{RMS}}Z$

AC Impedances: $Z_R = R \quad Z_C = 1/(2\pi fC) \quad Z_L = 2\pi fL$

AC Power: $P_{R,\text{ave}} = I_{\text{RMS}}V_{\text{RMS}} \quad P_{C,\text{ave}} = 0 \quad P_{L,\text{ave}} = 0$

Series Impedance: $X = Z_L - Z_C \quad Z_{\text{eq}} = \sqrt{X^2 + R^2}$

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

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Oscillations/Waves:

Fundamental: $v = f\lambda = \frac{\lambda}{T}$ $\quad f = 1/T$ $\quad \omega = 2\pi f$ $\quad k = \frac{2\pi}{\lambda}$

$x = x_{\max}\sin(kx - \omega t + \phi_0)$

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

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

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

Standing Waves: Similar Ends: $2L = i\lambda$ $\quad f = if_0, i =$ integer

Different Ends: $4L = i\lambda$ $\quad f = if_0, i =$ odd

$2L = \left(m + \frac{1}{2}\right)\lambda$ $\quad$ (m=integer; equivalent to above)

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

Rayleigh criterion: $\theta_{\min} = 1.22\frac{\lambda}{D}$ **Polarizer:** $I = I_0\cos^2\theta$

Light and Optics

Nature of Light: $E_\gamma = hf$ $\quad v_n = c/n$ $\quad \lambda_n = \lambda_0/n$

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 $d_{\text{np}} = 25$ cm) $\quad \theta_{\text{with}} = h/f$ (relaxed eyes)

$m = \frac{25\text{ cm}}{f}$ (relaxed eyes) $\quad m = \frac{25\text{ cm}}{f} + 1$ (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: $h' = -\theta_{\text{object}}f_o$ $\quad \theta_{\text{without}} = -h'/f_o$ $\quad \theta_{\text{with}} = h'/f_e$ $\quad m = -\frac{f_o}{f_e}$