

PHY 211

$$\vec{v}(t) = \frac{d\vec{r}(t)}{dt}$$

$$\vec{v}(t) = \frac{dx(t)}{dt}\hat{i} + \frac{dy(t)}{dt}\hat{j} + \frac{dz(t)}{dt}\hat{k}$$

$$\vec{a}(t) = \frac{d\vec{v}(t)}{dt} = \frac{d^2\vec{r}(t)}{dt^2}$$

$$x(t) = x_0 + \int_0^t v(t)dt$$

$$v(t) = v_0 + \int_0^t a(t)dt$$

$$x_f = x_i + v_i t + \frac{1}{2}at^2$$

$$v_f = v_i + at$$

$$v_f^2 = v_i^2 + 2a(x_f - x_i)$$

$$v_{\text{avg}} = \frac{1}{2}(v_f + v_i) = \frac{\Delta x}{\Delta t}$$

$$\vec{F}_{\text{net}} = \sum \vec{F}_i = m\vec{a}$$

$$\vec{F}_g = m\vec{g}$$

$$|\vec{F}_s| \leq \mu_s |\vec{N}|$$

$$|\vec{F}_k| = \mu_k |\vec{N}|$$

$$\vec{F}_{\text{spr}} = -k\Delta\vec{L}$$

$$\vec{F}_P = \vec{F}_N = P\vec{A}$$

$$Y = \frac{\Delta P}{\Delta L/L_0}$$

$$S = \frac{\Delta P}{\Delta x/h}$$

$$\vec{v}_t = \vec{r} \times \vec{\omega}$$

$$a_c = \frac{v_t^2}{r} = r\omega^2 = v_t\omega$$

$$\vec{a} = \vec{a}_c + \vec{a}_t$$

$$\vec{F}_G = -G\frac{m_1 m_2}{r^2}\hat{r}$$

$$g = G\frac{m_{\text{earth}}}{r_{\text{earth}}^2}$$

$$W = \vec{F} \cdot \vec{d} = Fd\cos(\theta)$$

$$W = \int_{x_i}^{x_f} F_x dx$$

$$W = \int_{P_i}^{P_f} \vec{F} \cdot d\vec{\ell}$$

$$P_{\text{av}} = \frac{\Delta W}{\Delta t}$$

$$P = \frac{dW}{dt}$$

$$\text{KE} = K = \frac{1}{2}mv^2$$

$$W_{\text{net}} = \Delta K$$

$$W_{\text{cons}} = -\Delta U = -\Delta \text{PE}$$

$$K_1 + U_1 = K_2 + U_2$$

$$\text{PE}_G = U_G = -G\frac{m_1 m_2}{r}$$

$$U_G = mgh$$

$$\text{PE}_S = U_S = \frac{1}{2}kx^2$$

$$F_x(x) = -\frac{dU(x)}{dx}$$

$$F_x(x) = -kx$$

$$\vec{r}_{\text{cm}} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i}$$

$$\vec{v}_{\text{cm}} = \frac{\sum_i m_i \vec{v}_i}{\sum_i m_i}$$

$$\vec{a}_{\text{cm}} = \frac{\sum_i m_i \vec{a}_i}{\sum_i m_i}$$

$$\vec{p} = m\vec{v}$$

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{p}_{1,f} + \vec{p}_{2,f} = \vec{p}_{1,i} + \vec{p}_{2,i}$$

$$\sum_i \vec{p}_i + \sum_i \vec{F}_{\text{ext}} \Delta t = \sum_i \vec{p}_f$$

$$\vec{J} = \vec{F} \Delta t = \Delta \vec{p}$$

$$\theta = \frac{s}{r}$$

$$\omega = \frac{d\theta}{dt} = \frac{v_t}{r}$$

$$\alpha = \frac{d\omega}{dt} = \frac{a_t}{r}$$

$$\vec{\tau} = \vec{r} \times \vec{F} = I\vec{\alpha}$$

$$\tau = r_{\perp} F, \quad r_{\perp} = r \sin(\theta)$$

$$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$$

$$L = rmv \sin(\theta)$$

$$\sum_i \vec{\tau}_i = \frac{d\vec{L}}{dt}$$

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega_f^2 = \omega_i^2 + 2\alpha(\theta_f - \theta_i)$$

$$\omega_{\text{avg}} = \frac{1}{2}(\omega_f + \omega_i)$$

$$K_{\text{rot}} = \frac{1}{2}I\omega^2$$

$$W = \tau \Delta \theta$$

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$\omega = \sqrt{\frac{k}{m}}$$

$$\omega = \sqrt{\frac{g}{\ell}}$$

$$\omega = \sqrt{\frac{mgl_{\text{CM}}}{I}}$$

$$x(t) = x_0 \sin(\omega t)$$

$$v(t) = -x_0 \omega \cos(\omega t)$$

$$a(t) = -x_0 \omega^2 \sin(\omega t)$$

$$v = f\lambda$$

$$v = \sqrt{\frac{F}{\mu}}; \quad \mu = \frac{m}{\ell}$$

$$k = \frac{2\pi}{\lambda}$$

$$y(x, t) = A \sin(kx) \sin(\omega t)$$

$$f_{\text{string}} = f_{\text{open-open}} = n \left(\frac{v}{2\ell} \right)$$

$$\text{where } n \in \{1, 2, 3, \dots\}$$

$$f_{\text{open-closed}} = n \left(\frac{v}{4\ell} \right)$$

$$\text{where } n \in \{1, 3, 5, \dots\}$$

$$y_{\text{tw}}(x, t) = A \sin(kx \mp \omega t)$$

$$f_o = f_s \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

$$f_{\text{beat}} = |f_2 - f_1|$$

$$I = \frac{P}{A} = \frac{P}{4\pi r^2}$$

$$I_0 \equiv 1.0 \times 10^{-12} \frac{\text{W}}{\text{m}^2}$$

$$\beta[\text{dB}] = 10 \log_{10} \left(\frac{I}{I_0} \right)$$

$$P = \frac{F}{A}$$

$$\rho = \frac{m}{V}$$

$$\vec{F}_b = -\rho V \vec{g}$$

$$P = P_0 + \rho gh$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

$$Q = \Phi_v \equiv \vec{v} \cdot \vec{A} = vA \cos(\theta)$$

$$Q = \frac{\Delta V}{\Delta t}$$

$$A_1 v_1 = A_2 v_2$$

$$\rho v A = \frac{\Delta m}{\Delta t}$$

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta V = \beta V_0 \Delta T$$

circumference of a circle $C = 2\pi r$

area of a circle $A = \pi r^2$

surface area of a sphere $A = 4\pi r^2$

volume of a sphere $V = \frac{4}{3}\pi r^3$

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

$\log_a(xy) = \log_a(x) + \log_a(y)$

$\log_a\left(\frac{x}{y}\right) = \log_a(x) - \log_a(y)$

$\log_a(x^y) = y \log_a(x)$

If $a^x = y$, $x = \log_a y = \frac{\log_{10} y}{\log_{10} a} = \frac{\ln y}{\ln a}$

If $|\theta| < 0.5$ radians, $\sin(\theta) \approx \theta$ (in radians)

$$\left. \begin{array}{l} x = r \cos(\theta) \\ y = r \sin(\theta) \end{array} \right\} \iff \left\{ \begin{array}{l} r = \sqrt{x^2 + y^2} \\ \theta = \tan^{-1}(y/x) + \begin{cases} 0^\circ, & \text{if } x > 0 \\ 180^\circ, & \text{otherwise} \end{cases} \end{array} \right.$$

If $\vec{R} = \vec{A} + \vec{B}$, $R_x = A_x + B_x$ and $R_y = A_y + B_y$

If $\vec{R} = \vec{A} - \vec{B}$, $R_x = A_x - B_x$ and $R_y = A_y - B_y$

Newton's constant $G = 6.67430 \times 10^{-11} \frac{\text{m}^3}{\text{kg} \cdot \text{s}^2}$

speed of light $c = 2.99792458 \times 10^8 \text{ m/s}$

elementary charge $e = 1.602176634 \times 10^{-19} \text{ C}$

electrostatic constant $k = 8.987551792 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2}$

vacuum permittivity $\epsilon_0 = 8.854187813 \times 10^{-12} \text{ F/m}$

vacuum permeability $\mu_0 = 4\pi \times 10^{-7} \text{ N} \cdot \text{A}^{-2}$

Planck's constant $h = 6.62607015 \times 10^{-34} \text{ J} \cdot \text{s}$

$\hbar \equiv \frac{h}{2\pi} = 1.054571817 \times 10^{-34} \text{ J} \cdot \text{s}$

standard gravity $g = +9.80665 \frac{\text{m}}{\text{s}^2}$

mass of earth $m_{\text{earth}} = 5.9723 \times 10^{24} \text{ kg}$

mass of moon $m_{\text{moon}} = 7.346 \times 10^{22} \text{ kg}$

mass of sun $m_{\text{sun}} = 1.9885 \times 10^{30} \text{ kg}$

mass of electron $m_e = 9.1093837015 \times 10^{-31} \text{ kg}$

mass of proton $m_p = 1.67262192369 \times 10^{-27} \text{ kg}$

mass of neutron $m_n = 1.67492749804 \times 10^{-27} \text{ kg}$

If $|\theta| < 0.5$ radians, $\tan(\theta) \approx \theta$ (in radians)

$\sin(-\theta) = -\sin(\theta)$

$\cos(-\theta) = \cos(\theta)$

$\sin(\theta_A + \theta_B) = \sin(\theta_A) \cos(\theta_B) + \cos(\theta_A) \sin(\theta_B)$

$\cos(\theta_A + \theta_B) = \cos(\theta_A) \cos(\theta_B) - \sin(\theta_A) \sin(\theta_B)$

$\sin(\theta_A) \sin(\theta_B) = \frac{\cos(\theta_A - \theta_B) - \cos(\theta_A + \theta_B)}{2}$

$\cos(\theta_A) \cos(\theta_B) = \frac{\cos(\theta_A - \theta_B) + \cos(\theta_A + \theta_B)}{2}$

$\sin(\theta_A) \cos(\theta_B) = \frac{\sin(\theta_A - \theta_B) + \sin(\theta_A + \theta_B)}{2}$

Law of Cosines $c^2 = a^2 + b^2 - 2ab \cos(C)$

Law of Sines $\frac{a}{\sin(A)} = \frac{b}{\sin(B)} = \frac{c}{\sin(C)}$

$\vec{A} \cdot \vec{B} = \vec{B} \cdot \vec{A} = A_x B_x + A_y B_y + A_z B_z = |\vec{A}| |\vec{B}| \cos(\theta)$

$|\vec{A} \times \vec{B}| = |\vec{A}| |\vec{B}| |\sin(\theta)|$

volumetric radius of earth $r_{\text{earth}} = 6.371 \times 10^6 \text{ m}$

earth-moon distance $r_{\text{EM}} = 3.844 \times 10^8 \text{ m}$

earth-sun distance $r_{\text{ES}} = 1.496 \times 10^{11} \text{ m}$

Density of air at sea level at 15° C:

$$\rho_0 = 1.225 \frac{\text{kg}}{\text{m}^3}$$

Earth's total magnetic field strength at Huntington, WV:

$$|\vec{B}_{\text{earth}}| \approx 5.15 \times 10^{-5} \text{ T}$$

Vertical component of Earth's magnetic field strength at Huntington, WV:

$$B_{\text{earth},z} \approx 4.70 \times 10^{-5} \text{ T}$$

$$\begin{aligned} \text{Bohr radius } a_B &\equiv \frac{\hbar^2}{m_e k e^2} \\ &= 5.29177210903 \times 10^{-11} \text{ m} \end{aligned}$$

$$\begin{aligned} \text{Rydberg constant } \mathcal{R} &\equiv \frac{\hbar}{4\pi m_e a_B^2 c} \\ &= 1.0973731568160 \times 10^7 \text{ m}^{-1} \end{aligned}$$

hydrogen binding energy $E_0 = 13.605693123 \text{ eV}$

scale for nuclear radius $r_{\text{nuc}} = 1.2 \times 10^{-15} \text{ m}$

$$1 \text{ newton [N]} \equiv 1 \frac{\text{kilogram} \cdot \text{meter}}{\text{second}^2}$$

$$1 \text{ joule [J]} \equiv 1 \text{ newton} \cdot \text{meter}$$

$$1 \text{ watt [W]} = 1 \frac{\text{joule}}{\text{second}}$$

$$1 \text{ radian} \equiv \frac{180^\circ}{\pi} \approx 57.29577951^\circ$$

$$1 \frac{\text{radian}}{\text{second}} \equiv \frac{60}{2\pi} \text{ rpm}$$

$$\approx 9.549296586 \text{ rpm}$$

$$1 \text{ hertz [Hz]} \equiv 1 \text{ second}^{-1}$$

$$1 \text{ pascal [Pa]} \equiv 1 \frac{\text{newton}}{\text{meter}^2}$$

$$1 \text{ volt [V]} \equiv 1 \frac{\text{joule}}{\text{coulomb}}$$

$$1 \text{ electron - volt [eV]} = 1.602176565 \times 10^{-19} \text{ joule}$$

$$1 \text{ farad [F]} \equiv 1 \frac{\text{coulomb}}{\text{volt}}$$

$$1 \text{ ampere [A]} \equiv 1 \frac{\text{coulomb}}{\text{second}}$$

$$1 \text{ ohm } [\Omega] \equiv 1 \frac{\text{volt}}{\text{ampere}}$$

$$1 \text{ tesla} \equiv 1 \frac{\text{newton}}{\text{ampere} \cdot \text{meter}}$$

$$1 \text{ gauss [G]} \equiv 10^{-4} \text{ tesla}$$

$$1 \text{ henry [H]} \equiv 1 \text{ ohm} \cdot \text{second}$$

$$1 \text{ diopter [D]} \equiv 1 \text{ meter}^{-1}$$

$$1 \text{ dalton [u]} = 1.66053873 \times 10^{-27} \text{ kilogram}$$

$$1 \text{ becquerel [Bq]} \equiv 1 \frac{\text{decay}}{\text{second}}$$

$$1 \text{ curie [Ci]} \equiv 3.7 \times 10^{10} \text{ becquerel}$$

$$1 \text{ rad} \equiv 0.01 \frac{\text{joule}}{\text{kilogram}}$$

$$1 \text{ gray} \equiv 1 \frac{\text{joule}}{\text{kilogram}} = 100 \text{ rad}$$

$$1 \text{ rem} \equiv 1 \text{ rad} \cdot RBE$$

$$1 \text{ sievert [Sv]} \equiv 1 \text{ gray} \cdot RBE = 100 \text{ rem}$$

$$1 \text{ inch [in]} \equiv 0.0254 \text{ meter}$$

$$1 \text{ foot [ft]} = 0.3048 \text{ meter}$$

$$1 \text{ mile [mi]} = 1609.344 \text{ meter}$$

$$1 \text{ light year [ly]} = 9.4605284 \times 10^{15} \text{ meter}$$

$$1 \text{ ounce mass [oz]} = 0.02835 \text{ kilogram}$$

$$1 \text{ pound mass [lb]} = 0.4536 \text{ kilogram}$$

$$1 \text{ mile per hour [mph]} = 0.44704 \frac{\text{meter}}{\text{second}}$$

$$1 \text{ foot pound [ft} \cdot \text{lb]} = 1.3558179 \text{ joule}$$

$$1 \text{ centipoise [cP]} \equiv 0.1 \text{ pascal} \cdot \text{second}$$

$$1 \text{ kiloton [kt]} = 4.184 \times 10^{12} \text{ joule}$$

$$1 \text{ horsepower [hp]} = 745.69987 \text{ watt}$$

$$1 \text{ atmosphere [atm]} = 1.0132501 \times 10^5 \text{ pascal}$$

$$1 \text{ mm of mercury [mmHg]} = 133.32239 \text{ pascal}$$

$$1 \text{ pound per square inch [psi]} = 6894.75728 \text{ pascal}$$

Prefixes

giga [G]: 10^9	kilo [k]: 10^3	milli [m]: 10^{-3}	nano [n]: 10^{-9}	femto [f]: 10^{-15}
mega [M]: 10^6	centi [c]: 10^{-2}	micro [μ]: 10^{-6}	pico [p]: 10^{-12}	

Moments of Inertia

hoop about axis $I = mr^2$	thin rod, axis through end \perp to length $I = \frac{1}{3}m\ell^2$
point particle about axis at distance r $I = mr^2$	solid sphere about diameter $I = \frac{2}{5}mr^2$
ring about axis $I = \frac{1}{2}m(r_1^2 + r_2^2)$	thin spherical shell about diameter $I = \frac{2}{3}mr^2$
solid disk about axis $I = \frac{1}{2}mr^2$	hoop about any diameter $I = \frac{1}{2}mr^2$
solid disk about diameter $I = \frac{1}{4}mr^2 + \frac{1}{12}m\ell^2$	slab about \perp axis through center $I = \frac{1}{2}m(\ell_x^2 + \ell_y^2)$
thin rod, axis through center \perp to length $I = \frac{1}{12}m\ell^2$	

PHY 213

$$Q = Ne$$

$$\vec{F} = \frac{1}{4\pi\epsilon_0} \frac{|q_1q_2|}{r^2} \hat{r} = k \frac{|q_1q_2|}{r^2} \hat{r}$$

$$\vec{E} = \frac{\vec{F}}{q} = k \frac{q}{r^2} \hat{r}$$

$$\vec{E} = k \int \frac{dq}{r^2} \hat{r}$$

$$\vec{\tau} = \vec{p} \times \vec{E}; \vec{p} = q\vec{d}$$

$$U = -\vec{p} \cdot \vec{E}$$

$$PE = U = k \frac{q_1q_2}{r}$$

$$V = \frac{U}{q} = -\frac{W}{q}$$

$$V_a - V_b = \int_a^b \vec{E} \cdot d\vec{\ell}$$

$$V = k \frac{q}{r} = k \sum \frac{q_i}{r_i}$$

$$\vec{E} = -\left(\hat{i} \frac{\partial V}{\partial x} + \hat{j} \frac{\partial V}{\partial y} + \hat{k} \frac{\partial V}{\partial z}\right)$$

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\epsilon_0}$$

$$\Phi_E = \vec{E} \cdot \vec{A} = AE \cos \theta$$

$$C = \frac{q}{V}$$

$$C_0 = \frac{\epsilon_0 A}{d}$$

$$C = KC_0 = \frac{K\epsilon_0 A}{d} = \frac{\epsilon A}{d}$$

$$\frac{1}{C_{\text{series}}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

$$C_{\text{parallel}} = C_1 + C_2 + \dots$$

$$U = \frac{1}{2} qV = \frac{1}{2} \frac{q^2}{C} = \frac{1}{2} CV^2$$

$$u = \frac{\epsilon_0}{2} E^2$$

$$I = \frac{dq}{dt}$$

$$I = nqAv_{\text{drift}}$$

$$\vec{J} = nq\vec{v}_{\text{drift}}$$

$$V_{ab} = \mathcal{E} - Ir$$

$$V = IR$$

$$R = \frac{\rho \ell}{A}$$

$$\rho = \rho_0(1 + \alpha \Delta T)$$

$$R = R_0(1 + \alpha \Delta T)$$

$$P = IV = \frac{V^2}{R} = I^2 R$$

$$\sum I_i = 0$$

$$\sum V_i = 0$$

$$R_{\text{series}} = R_1 + R_2 + \dots$$

$$\frac{1}{R_{\text{parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

$$\tau = RC$$

$$q = C\mathcal{E}(1 - e^{-t/RC})$$

$$i = \frac{\mathcal{E}}{R} e^{-t/RC} = I_0 e^{-t/RC}$$

$$q = Q_0 e^{-t/RC}$$

$$\vec{F}_B = q\vec{v} \times \vec{B}$$

$$R = \frac{mv}{qB}$$

$$\vec{F} = I\vec{\ell} \times \vec{B}$$

$$\vec{\mu} = NI\vec{A}$$

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

$$\tau = \mu B \sin \phi$$

$$U = -\vec{\mu} \cdot \vec{B} = -\mu B \cos \phi$$

$$\Phi_B \equiv \oint \vec{B} \cdot d\vec{A}$$

$$\Phi_B = \vec{B} \cdot \vec{A} = AB \cos(\theta)$$

$$\vec{B} = \frac{\mu_0 q\vec{v} \times \hat{r}}{4\pi r^2}$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{N\mu_0 I}{2r}$$

$$B = \frac{N\mu_0 I}{\ell} = n\mu_0 I$$

$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{\text{encl}}$$

$$\mathcal{E} = -\frac{d\Phi_{\text{tot}}}{dt} = -N \frac{d\Phi}{dt}$$

$$\oint \vec{E} \cdot d\vec{\ell} = -\frac{d\Phi_B}{dt}$$

$$\mathcal{E} = vBL$$

$$\mathcal{E} = NAB\omega \sin(\omega t)$$

$$M = \frac{N_2 \Phi_{B2}}{i_1} = \frac{N_1 \Phi_{B1}}{i_2}$$

$$L = \frac{N\Phi_B}{i}$$

$$\mathcal{E} = -L \frac{di}{dt}$$

$$U = L \int_0^I idi = \frac{1}{2} LI^2$$

$$u = \frac{B^2}{2\mu_0}$$

$$\tau = \frac{L}{R}$$

$$i = \frac{\mathcal{E}}{R} (1 - e^{-t/\tau})$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$q = Q \cos(\omega t)$$

$$i = -\omega Q \sin(\omega t)$$

$$\omega' = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$

$$i = I \cos(\omega t)$$

$$I_{\text{rms}} = \frac{I}{\sqrt{2}}; V_{\text{rms}} = \frac{V}{\sqrt{2}}$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{\omega C}$$

$$X_L = 2\pi f L = \omega L$$

$$Z_{\text{total}} = \sqrt{R^2 + (X_L - X_C)^2}$$

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z}$$

$$\tan \phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$$

$$P_{\text{av}} = \frac{1}{2} VI \cos \phi$$

$$P_{\text{av}} = I_{\text{rms}} V_{\text{rms}} \cos \phi$$

$$\omega_{\text{res}} = 2\pi f_{\text{res}} = \frac{1}{\sqrt{LC}}$$

$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$

$$E_{\text{max}} = cB_{\text{max}}$$

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

$$v = \frac{1}{\sqrt{\mu\epsilon}} = \frac{c}{\sqrt{KK_m}}$$

$$n = \frac{c}{v}$$

$$c = f\lambda$$

$$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

$$I_{\text{av}} = S_{\text{av}} = \frac{E_{\text{max}} B_{\text{max}}}{2\mu_0}$$

$$p_{\text{rad,abs}} = \frac{I}{c}; p_{\text{rad,ref}} = \frac{2I}{c}$$

$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

$$\lambda = \frac{\lambda_0}{n}$$

$$\theta_{\text{crit}} = \sin^{-1} \left(\frac{n_2}{n_1} \right)$$

$$I = I_{\text{max}} \cos^2(\phi)$$

$$\theta_{\text{pol}} = \tan^{-1} \left(\frac{n_2}{n_1} \right)$$

$$m = \frac{h_{\text{im}}}{h_{\text{ob}}} = -\frac{s_{\text{im}}}{s_{\text{ob}}}$$

$$f = \frac{R}{2}$$

$$P = \frac{1}{f} = \frac{1}{s_{\text{ob}}} + \frac{1}{s_{\text{im}}}$$

$$\frac{1}{f} = (n-1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

$$m = m_{\text{objective}} m_{\text{eyepiece}}$$

$$M = \frac{\theta'}{\theta} = \frac{25\text{cm}}{f}$$

$$M = \frac{\theta_{\text{telescope}}}{\theta_{\text{nailed eye}}} = -\frac{f_o}{f_e}$$

$$d \sin(\theta) = m\lambda \quad (\text{max})$$

$$\text{where } m \in \{0, \pm 1, \pm 2, \dots\}$$

$$d \sin(\theta) = (m + \frac{1}{2}) \lambda \quad (\text{min})$$

$$\text{where } m \in \{0, \pm 1, \pm 2, \dots\}$$

$$y = R \frac{m\lambda}{d}$$

$$I = I_0 \cos^2(\phi/2)$$

$$\phi = \frac{2\pi}{\lambda} (r_2 - r_1)$$

$$2t = m\lambda$$

$$\text{where } m \in \{0, 1, 2, \dots\}$$

$$2t = (m + \frac{1}{2}) \lambda$$

$$\text{where } m \in \{0, 1, 2, 3, \dots\}$$

$$a \sin(\theta) = m\lambda \quad (\text{min})$$

$$\text{where } m \in \{\pm 1, \pm 2, \dots\}$$

$$I = I_0 \left[\frac{\sin(\phi/2)}{\beta/2} \right]^2$$

$$\beta = \frac{2\pi}{\lambda} a \sin(\theta)$$

$$\sin(\theta) = 1.22 \frac{\lambda}{D}$$

$$2d \sin(\theta) = m\lambda$$

$$\text{where } m \in \{1, 2, 3, \dots\}$$

$$E_{\text{photon}} = hf = \frac{hc}{\lambda} = pc$$

$$K_{\text{max}} = hf - \Phi$$

$$\lambda' - \lambda = \frac{h}{mc} (1 - \cos(\phi))$$

$$\Delta x \Delta p_x \geq \frac{\hbar}{2}; \Delta t \Delta E \geq \frac{\hbar}{2}$$

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

$$E_n = -\frac{hcR}{n^2}; R = \frac{me^4}{8\epsilon_0^2 h^3 c}$$