PHY 211

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

$$\vec{v}(t) = \frac{\mathrm{d}x(t)}{\mathrm{d}t}\hat{\imath} + \frac{\mathrm{d}y(t)}{\mathrm{d}t}\hat{\jmath} + \frac{\mathrm{d}z(t)}{\mathrm{d}t}\hat{k}$$

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

$$x(t) = x_0 + \int_0^t v(t)\mathrm{d}t$$

$$v(t) = v_0 + \int_0^t a(t)\mathrm{d}t$$

$$x_\mathrm{f} = x_\mathrm{i} + v_\mathrm{i}t + \tfrac{1}{2}at^2$$

$$v_\mathrm{f} = v_\mathrm{i} + at$$

$$v_\mathrm{f}^2 = v_\mathrm{i}^2 + 2a(x_\mathrm{f} - x_\mathrm{i})$$

$$v_\mathrm{avg} = \tfrac{1}{2}(v_\mathrm{f} + v_\mathrm{i}) = \frac{\Delta x}{\Delta t}$$

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

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

$$|\vec{F}_\mathrm{s}| \le \mu_\mathrm{s}|\vec{N}|$$

$$|\vec{F}_\mathrm{k}| = \mu_\mathrm{k}|\vec{N}|$$

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

$$\vec{F}_\mathrm{P} = \vec{F}_\mathrm{N} = P\vec{A}$$

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

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

$$\vec{v_t} = \vec{r} \times \vec{\omega}$$

$$a_\mathrm{c} = \frac{v_\mathrm{t}^2}{r} = r\omega^2 = v_t\omega$$

$$\vec{a} = \vec{a_\mathrm{c}} + \vec{a_t}$$

$$\vec{F}_G = -G\frac{m_1m_2}{r^2}\hat{r}$$

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

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

$$W = \int_{x_\mathrm{i}}^{x_\mathrm{f}} F_x \mathrm{d}x$$

$$W = \int_{P_\mathrm{i}}^{P_\mathrm{f}} \vec{F}\cdot\mathrm{d}\vec{\ell}$$

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

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

$$\mathrm{KE} = K = \tfrac{1}{2}mv^2$$

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

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

$$K_1 + U_1 = K_2 + U_2$$

$$\mathrm{PE}_G = U_G = -G\frac{m_1m_2}{r}$$

$$U_G = mgh$$

$$\mathrm{PE_S} = U_\mathrm{S} = \tfrac{1}{2}kx^2$$

$$F_x(x) = -\frac{\mathrm{d}U(x)}{\mathrm{d}x}$$

$$F_x(x) = -kx$$

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

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

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

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

$$\vec{F} = \frac{\mathrm{d}\vec{p}}{\mathrm{d}t}$$

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

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

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

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

$$\omega = \frac{d\theta}{dt} = \frac{v_\mathrm{t}}{r}$$

$$\alpha = \frac{d\omega}{dt} = \frac{a_\mathrm{t}}{r}$$

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

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

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

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

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

$$\theta_\mathrm{f} = \theta_\mathrm{i} + \omega_\mathrm{i}t + \tfrac{1}{2}\alpha t^2$$

$$\omega_\mathrm{f} = \omega_\mathrm{i} + \alpha t$$

$$\omega_\mathrm{f}^2 = \omega_\mathrm{i}^2 + 2\alpha(\theta_\mathrm{f} - \theta_\mathrm{i})$$

$$\omega_\mathrm{avg} = \tfrac{1}{2}(\omega_\mathrm{f} + \omega_\mathrm{i})$$

$$K_\mathrm{rot} = \tfrac{1}{2}I\omega^2$$

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

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

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

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

$$\omega = \sqrt{\frac{mg\ell_\mathrm{CM}}{I}}$$

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

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

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

$$v = f\lambda$$

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

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

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

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

where $n \in \{1,2,3,\ldots\}$

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

where $n \in \{1,3,5,\ldots\}$

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

$$f_\mathrm{o} = f_\mathrm{s}\left(\frac{v \pm v_\mathrm{o}}{v \mp v_\mathrm{s}}\right)$$

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

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

$$I_0 \equiv 1.0\times10^{-12}\,\frac{\mathrm{W}}{\mathrm{m}^2}$$

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

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

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

$$\vec{F}_\mathrm{b} = -\rho V\vec{g}$$

$$P = P_0 + \rho gh$$

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho gy_1 = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho gy_2$$

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

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

$$A_1v_1 = A_2v_2$$

$$\rho vA = \frac{\Delta m}{\Delta t}$$

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

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

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

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

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

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

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)

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

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

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 $R_y = A_y - B_y$

$$\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A} = A_xB_x + A_yB_y + A_zB_z = |\vec{A}||\vec{B}|\cos(\theta)$$

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

Newton's constant $G = 6.67430\times10^{-11}\ \frac{\mathrm{m}^3}{\mathrm{kg\cdot s^2}}$

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

elementary charge $e = 1.602176634\times10^{-19}$ C

electrostatic constant $k = 8.987551792\times10^9\,\frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}}$

vacuum permittivity $\epsilon_0 = 8.854187813\times10^{-12}$ F/m

vacuum permeability $\mu_0 = 4\pi\times10^{-7}\ \mathrm{N\cdot A^{-2}}$

Planck's constant $h = 6.62607015\times10^{-34}$ J · s

$\hbar \equiv \frac{h}{2\pi} = 1.054571817\times10^{-34}$ J · s

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

mass of earth $m_{\mathrm{earth}} = 5.9723\times10^{24}$ kg

mass of moon $m_{\mathrm{moon}} = 7.346\times10^{22}$ kg

mass of sun $m_{\mathrm{sun}} = 1.9885\times10^{30}$ kg

mass of electron $m_{\mathrm{e}} = 9.1093837015\times10^{-31}$ kg

mass of proton $m_{\mathrm{p}} = 1.67262192369\times10^{-27}$ kg

mass of neutron $m_{\mathrm{n}} = 1.67492749804\times10^{-27}$ kg

volumetric radius of earth $r_{\mathrm{earth}} = 6.371\times10^6$ m

earth-moon distance $r_{\mathrm{EM}} = 3.844\times10^8$ m

earth-sun distance $r_{\mathrm{ES}} = 1.496\times10^{11}$ m

Density of air at sea level at 15° C:

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

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

$$|\vec{B}_{\mathrm{earth}}| \approx 5.15\times10^{-5}\ \mathrm{T}$$

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

$$B_{\mathrm{earth},z} \approx 4.70\times10^{-5}\ \mathrm{T}$$

Bohr radius $a_B \equiv \frac{\hbar^2}{m_\mathrm{e} k e^2} = 5.29177210903\times10^{-11}$ m

Rydberg constant $\mathcal{R} \equiv \frac{\hbar}{4\pi m_\mathrm{e} a_B^2 c} = 1.0973731568160 \times 10^7\ \mathrm{m}^{-1}$

hydrogen binding energy $E_0 = 13.605693123$ eV

scale for nuclear radius $r_{\mathrm{nuc}} = 1.2\times10^{-15}$ m

$$1 \text{ newton [N]} \equiv 1 \ \frac{\text{kilogram} \cdot \text{meter}}{\text{second}^2}$$
$$1 \text{ joule [J]} \equiv 1 \text{ newton} \cdot \text{meter}$$
$$1 \text{ watt [W]} = 1 \ \frac{\text{joule}}{\text{second}}$$
$$1 \text{ radian} \equiv \frac{180°}{\pi} \approx 57.29577951°$$
$$1 \ \frac{\text{radian}}{\text{second}} \equiv \frac{60}{2\pi} \text{ rpm} \approx 9.549296586 \text{ rpm}$$
$$1 \text{ hertz [Hz]} \equiv 1 \text{ second}^{-1}$$
$$1 \text{ pascal [Pa]} \equiv 1 \ \frac{\text{newton}}{\text{meter}^2}$$
$$1 \text{ volt [V]} \equiv 1 \ \frac{\text{joule}}{\text{coulomb}}$$
$$1 \text{ electron} - \text{volt [eV]} = 1.602176565 \times 10^{-19} \text{joule}$$
$$1 \text{ farad [F]} \equiv 1 \ \frac{\text{coulomb}}{\text{volt}}$$
$$1 \text{ ampere [A]} \equiv 1 \ \frac{\text{coulomb}}{\text{second}}$$
$$1 \text{ ohm } [\Omega] \equiv 1 \ \frac{\text{volt}}{\text{ampere}}$$
$$1 \text{ tesla} \equiv 1 \ \frac{\text{newton}}{\text{ampere} \cdot \text{meter}}$$
$$1 \text{ gauss [G]} \equiv 10^{-4} \text{ tesla}$$
$$1 \text{ henry [H]} \equiv 1 \text{ ohm} \cdot \text{second}$$
$$1 \text{ diopter [D]} \equiv 1 \text{ meter}^{-1}$$
$$1 \text{ dalton [u]} = 1.66053873 \times 10^{-27} \text{ kilogram}$$

$$1 \text{ becquerel [Bq]} \equiv 1 \frac{\text{decay}}{\text{second}}$$
$$1 \text{ curie [Ci]} \equiv 3.7 \times 10^{10} \text{ becquerel}$$
$$1 \text{ rad} \equiv 0.01 \ \frac{\text{joule}}{\text{kilogram}}$$
$$1 \text{ gray} \equiv 1 \ \frac{\text{joule}}{\text{kilogram}} = 100 \text{ rad}$$
$$1 \text{ rem} \equiv 1 \text{ rad} \cdot RBE$$
$$1 \text{ sievert [Sv]} \equiv 1 \text{ gray} \cdot RBE = 100 \text{ rem}$$
$$1 \text{ inch [in]} \equiv 0.0254 \text{ meter}$$
$$1 \text{ foot [ft]} = 0.3048 \text{ meter}$$
$$1 \text{ mile [mi]} = 1609.344 \text{ meter}$$
$$1 \text{ light year [ly]} = 9.4605284 \times 10^{15} \text{ meter}$$
$$1 \text{ ouncemass [oz]} = 0.02835 \text{ kilogram}$$
$$1 \text{ poundmass [lb]} = 0.4536 \text{ kilogram}$$
$$1 \text{ mile per hour [mph]} = 0.44704 \ \frac{\text{meter}}{\text{second}}$$
$$1 \text{ foot pound [ft} \cdot \text{lb]} = 1.3558179 \text{ joule}$$
$$1 \text{ centipoise [cP]} \equiv 0.1 \text{ pascal} \cdot \text{second}$$
$$1 \text{ kiloton [kt]} = 4.184 \times 10^{12} \text{ joule}$$
$$1 \text{ horsepower [hp]} = 745.69987 \text{ watt}$$
$$1 \text{ atmosphere [atm]} = 1.0132501 \times 10^{5} \text{ pascal}$$
$$1 \text{ mm of mercury [mmHg]} = 133.32239 \text{ pascal}$$
$$1 \text{ pound per square inch [psi]} = 6894.75728 \text{ pascal}$$

Prefixes

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

Moments of Inertia

hoop about axis $I = mr^2$

point particle about axis at distance r $I = mr^2$

ring about axis $I = \frac{1}{2} m \left(r_1^2 + r_2^2\right)$

solid disk about axis $I = \frac{1}{2} mr^2$

solid disk about diameter $I = \frac{1}{4} mr^2 + \frac{1}{12} m\ell^2$

thin rod, axis through center $\perp$ to length $I = \frac{1}{12} m\ell^2$

thin rod, axis through end $\perp$ to length $I = \frac{1}{3} m\ell^2$

solid sphere about diameter $I = \frac{2}{5} mr^2$

thin spherical shell about diameter $I = \frac{2}{3} mr^2$

hoop about any diameter $I = \frac{1}{2} mr^2$

slab about $\perp$ axis through center $I = \frac{1}{2} m \left(\ell_x^2 + \ell_y^2\right)$

PHY 213

$$Q = Ne$$
$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}\hat{r} = k\frac{|q_1 q_2|}{r^2}\hat{r}$$
$$\vec{E} = \frac{\vec{F}}{q} = k\frac{q}{r^2}\hat{r}$$
$$\vec{E} = k\int\frac{\mathrm{d}q}{r^2}\hat{r}$$
$$\vec{\tau} = \vec{p}\times\vec{E}\ ;\ \vec{p} = q\vec{d}$$
$$U = -\vec{p}\cdot\vec{E}$$
$$\mathrm{PE} = U = k\frac{q_1 q_2}{r}$$
$$V = \frac{U}{q} = -\frac{\mathrm{W}}{q}$$
$$V_\mathrm{a} - V_\mathrm{b} = \int_\mathrm{a}^\mathrm{b}\vec{E}\cdot\mathrm{d}\vec{\ell}$$
$$V = k\frac{q}{r} = k\sum\frac{q_i}{r_i}$$
$$\vec{E} = -\left(\hat{\imath}\frac{\partial V}{\partial x} + \hat{\jmath}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$$
$$\Phi_E = \oint\vec{E}\cdot\mathrm{d}\vec{A} = \frac{q_\mathrm{enclosed}}{\epsilon_0}$$
$$\Phi_E = \vec{E}\cdot\vec{A} = AE\cos\theta$$
$$C = \frac{q}{V}$$
$$C_0 = \frac{\epsilon_0 A}{d}$$
$$C = KC_0 = \frac{K\epsilon_0 A}{d} = \frac{\epsilon A}{d}$$
$$\frac{1}{C_\mathrm{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$
$$C_\mathrm{parallel} = C_1 + C_2 + \dots$$
$$U = \frac{1}{2}qV = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}CV^2$$
$$u = \frac{\epsilon_0}{2}E^2$$
$$I = \frac{dq}{dt}$$
$$I = nqAv_\mathrm{drift}$$
$$\vec{J} = nq\vec{v}_\mathrm{drift}$$
$$V_{ab} = \mathcal{E} - Ir$$
$$V = IR$$
$$R = \frac{\rho\ell}{A}$$
$$\rho = \rho_0(1 + \alpha\Delta T)$$
$$R = R_0(1 + \alpha\Delta T)$$
$$P = IV = \frac{V^2}{R} = I^2R$$
$$\sum I_i = 0$$
$$\sum V_i = 0$$

$$R_\mathrm{series} = R_1 + R_2 + \dots$$
$$\frac{1}{R_\mathrm{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$
$$\tau = RC$$
$$q = C\mathcal{E}(1 - e^{-t/RC})$$
$$i = \frac{\mathcal{E}}{R}e^{-t/RC} = I_0 e^{-t/RC}$$
$$q = Q_0 e^{-t/RC}$$
$$\vec{F}_B = q\vec{v}\times\vec{B}$$
$$R = \frac{mv}{qB}$$
$$\vec{F} = I\vec{\ell}\times\vec{B}$$
$$\vec{\mu} = NI\hat{A}$$
$$\vec{\tau} = \vec{\mu}\times\vec{B}$$
$$\tau = \mu B\sin\phi$$
$$U = -\vec{\mu}\cdot\vec{B} = -\mu B\cos\phi$$
$$\Phi_B \equiv \oint\vec{B}\cdot\mathrm{d}\vec{A}$$
$$\Phi_B = \vec{B}\cdot\vec{A} = AB\cos(\theta)$$
$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$
$$B = \frac{\mu_0 I}{2\pi r}$$
$$B = \frac{N\mu_0 I}{2r}$$
$$B = \frac{N\mu_0 I}{\ell} = n\mu_0 I$$
$$\frac{F}{\ell} = \frac{\mu_0 I_1 I_2}{2\pi r}$$
$$\oint\vec{B}\cdot\vec{dl} = \mu_0 I_{encl}$$
$$\mathcal{E} = -\frac{d\Phi_\mathrm{tot}}{dt} = -N\frac{d\Phi}{dt}$$
$$\oint\vec{E}\cdot\vec{dl} = -\frac{d\Phi_B}{dt}$$
$$\mathcal{E} = vBL$$
$$\mathcal{E} = NAB\omega\sin(\omega t)$$
$$M = \frac{N_2\Phi_{B2}}{i_1} = \frac{N_1\Phi_{B1}}{i_2}$$
$$L = \frac{N\Phi_B}{i}$$
$$\mathcal{E} = -L\frac{di}{dt}$$
$$U = L\int_0^I i\,di = \frac{1}{2}LI^2$$
$$u = \frac{B^2}{2\mu_0}$$
$$\tau = \frac{L}{R}$$
$$i = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau})$$

$$\omega = \frac{1}{\sqrt{LC}}$$
$$q = Q\cos(\omega t)$$
$$i = -\omega Q\sin(\omega t)$$
$$\omega' = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$$
$$i = I\cos(\omega t)$$
$$I_\mathrm{rms} = \frac{I}{\sqrt{2}}\ ;\ V_\mathrm{rms} = \frac{V}{\sqrt{2}}$$
$$X_C = \frac{1}{2\pi fC} = \frac{1}{\omega C}$$
$$X_L = 2\pi fL = \omega L$$
$$Z_\mathrm{total} = \sqrt{R^2 + (X_L - X_C)^2}$$
$$I_\mathrm{rms} = \frac{V_\mathrm{rms}}{Z}$$
$$\tan\phi = \frac{V_L - V_C}{V_R} = \frac{X_L - X_C}{R}$$
$$P_\mathrm{av} = \frac{1}{2}VI\cos\phi$$
$$P_\mathrm{av} = I_\mathrm{rms}V_\mathrm{rms}\cos\phi$$
$$\omega_\mathrm{res} = 2\pi f_\mathrm{res} = \frac{1}{\sqrt{LC}}$$
$$\frac{V_\mathrm{S}}{V_\mathrm{P}} = \frac{N_\mathrm{S}}{N_\mathrm{P}} = \frac{I_\mathrm{P}}{I_\mathrm{S}}$$
$$E_\mathrm{max} = cB_\mathrm{max}$$
$$c = \frac{1}{\sqrt{\mu_0\epsilon_0}}$$
$$v = \frac{1}{\sqrt{\mu\epsilon}} = \frac{c}{\sqrt{KK_m}}$$
$$n = \frac{c}{v} = \frac{\lambda_0}{\lambda}$$
$$c = f\lambda$$
$$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$$
$$I_\mathrm{av} = S_\mathrm{av} = \frac{E_\mathrm{max}B_\mathrm{max}}{2\mu_0}$$
$$I = \frac{P_{source}}{A} = \frac{P_{source}}{4\pi r^2}$$
$$p_\mathrm{rad,abs} = \frac{I}{c}\ ;\ p_\mathrm{rad,ref} = \frac{2I}{c}$$
$$n_1\sin(\theta_1) = n_2\sin(\theta_2)$$
$$\lambda = \frac{\lambda_0}{n}$$
$$\theta_\mathrm{crit} = \sin^{-1}\left(\frac{n_2}{n_1}\right)$$
$$I = I_\mathrm{max}\cos^2(\phi) = \tfrac{1}{2}I_0\cos^2(\phi)$$
$$\theta_\mathrm{pol} = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$
$$m = \frac{h_\mathrm{im}}{h_\mathrm{ob}} = -\frac{s_\mathrm{im}}{s_\mathrm{ob}}$$
$$f = \frac{R}{2}$$

$$P = \frac{1}{f} = \frac{1}{s_\mathrm{ob}} + \frac{1}{s_\mathrm{im}}$$
$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$
$$m = m_\mathrm{objective}\ m_\mathrm{eyepiece}$$
$$M = \frac{\theta'}{\theta} = \frac{25cm}{f}$$
$$M = \frac{\theta_\mathrm{telescope}}{\theta_\mathrm{naked\ eye}} = -\frac{f_\mathrm{o}}{f_\mathrm{e}}$$

$d\sin(\theta) = m\lambda$ (max)
where $m \in \{0, \pm1, \pm2, \dots\}$

$d\sin(\theta) = \left(m + \frac{1}{2}\right)\lambda$ (min)
where $m \in \{0, \pm1, \pm2, \dots\}$

$$y = R\frac{m\lambda}{d}$$
$$I = I_0\cos^2(\phi/2)$$
$$\phi = \frac{2\pi}{\lambda}(r_2 - r_1)$$

$2t = m\lambda$
where $m \in \{0, 1, 2, \dots\}$

$2t = \left(m + \frac{1}{2}\right)\lambda$
where $m \in \{0, 1, 2, 3, \dots\}$

$a\sin(\theta) = m\lambda$ (min)
where $m \in \{\pm1, \pm2, \dots\}$

$$I = I_0\left[\frac{\sin(\phi/2)}{\beta/2}\right]^2$$
$$\beta = \frac{2\pi}{\lambda}a\sin(\theta)$$
$$\sin(\theta) = 1.22\frac{\lambda}{D}$$

$2d\sin(\theta) = m\lambda$
where $m \in \{1, 2, 3, \dots\}$

$$E_\mathrm{photon} = hf = \frac{hc}{\lambda} = pc$$
$$K_\mathrm{max} = hf - \Phi$$
$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos(\phi))$$
$$\Delta x\Delta p_x \geq \frac{\hbar}{2}\ ;\ \Delta t\Delta E \geq \frac{\hbar}{2}$$
$$\lambda = \frac{h}{p} = \frac{h}{mv}$$
$$E_n = -\frac{hcR}{n^2}\ ;\ R = \frac{me^4}{8\epsilon_0^2h^3c}$$