Hooke's Law:

$$F = -kx$$

SHM:

$$\begin{aligned} x(t) &= A\cos(\omega t) \\ v(t) &= \frac{dx(t)}{dt} \\ a(t) &= \frac{dv(t)}{dt} = \frac{d^2x(t)}{dt^2} \\ T &= \frac{1}{f} = \frac{2\pi}{\omega} \\ \omega &= \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{l}} \\ E &= \frac{1}{2}kA^2 = K + U = \frac{1}{2}mv^2 + \frac{1}{2}kx^2 \end{aligned}$$

Damped Oscillation:

$$\begin{aligned} x(t) &= A\exp(-bt/2m)\cos(\omega t + \phi) \\ \omega &= \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2} \end{aligned}$$

Waves:

$$\begin{aligned} y(x,t) &= f(x \mp vt) = Asin(kx \mp \omega t) \\ k &= \frac{2\pi}{\lambda} \\ \omega &= \frac{2\pi}{T} \\ v &= \frac{\lambda}{T} \\ v &= \sqrt{\frac{T}{\mu}} \\ E &= \frac{1}{2}\mu\omega^2 A^2 \lambda \\ P &= \frac{1}{2}\mu\omega^2 A^2 v \end{aligned}$$

Doppler Shift:

(source and observer moving towards each other)

$$f' = f\left(\frac{v + v_0}{v - v_s}\right)$$

Standing Waves:

$$y(x,t) = \Big[2A\sin(kx)\Big]\cos(\omega t)$$

Path/Phase difference:

$$\Delta r = \frac{\Delta\phi}{2\pi}\lambda$$

String/Open-End Pipe:

$$f_n = \frac{v}{\lambda_n} = n\frac{v}{2L} = nf_1 \qquad n = 1, 2, \ldots$$

Closed-End Pipe:

$$f_n = \frac{v}{\lambda_n} = (2n-1)\frac{v}{4L} = nf_1 \qquad n = 1, 2, \ldots$$

Beats:

$$f_b = |f_1 - f_2|$$

Radiation Pressure :

$$\begin{aligned} P &= S/c \quad \text{(black body)} \\ P &= 2S/c \quad \text{(Mirror)} \end{aligned}$$

Polarizers:

$$I = I_0\cos^2\theta$$

Geometric Optics:

Reflection

$$\theta = \theta'$$

Refraction

$$\begin{aligned} \frac{\sin\theta_1}{\sin\theta_2} &= \frac{v_1}{v_2} \\ n &= \frac{c}{v} \\ n_1\lambda_1 &= n_2\lambda_2 \\ n_1\sin\theta_1 &= n_2\sin\theta_2 \end{aligned}$$

Magnification

$$M = \frac{h'}{h} = -\frac{q}{p}$$

Mirror and lens equation

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

Image formed by refraction

$$\begin{aligned} \frac{n_1}{p} + \frac{n_2}{q} &= \frac{n_2 - n_1}{R} \\ \frac{n_1}{p} &= -\frac{n_2}{q} \end{aligned}$$

Lenses

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

Interference:

$$\begin{aligned} \frac{\delta}{\lambda} &= \frac{\phi}{2\pi} \\ \delta &= m\lambda \qquad m = 0, 1, 2, \ldots \qquad \text{Constructive} \\ \delta &= \left(m + \frac{1}{2}\right)\lambda \qquad m = 0, 1, 2, \ldots \qquad \text{Destructive} \end{aligned}$$

Double Slit Experiment

$$\begin{aligned} \delta &= d\sin\theta_{bright} = m\lambda \qquad m = 0, 1, 2, \ldots \\ \delta &= d\sin\theta_{dark} = \left(m + \frac{1}{2}\right)\lambda \qquad m = 0, 1, 2, \ldots \\ y_{bright} &= L\tan\theta_{bright} \\ y_{dark} &= L\tan\theta_{dark} \\ I_{max} &= \cos^2\left[\frac{\pi d\sin\theta}{\lambda}\right] \end{aligned}$$

Single Slit Diffraction

$$\sin\theta_{dark} = m\frac{\lambda}{a} \qquad m = 0, 1, 2, \ldots$$

Circular Aperture

$$\theta_{min} \approx 1.22\frac{\lambda}{D}$$

Diffraction Grating

$$d\sin\theta_{bright} = m\lambda \qquad m = 0, 1, 2, \ldots$$

Quantum Physics:

Blackbody

$$\begin{aligned} P &= \sigma A T^4 \\ \lambda_{max} T &= 2.898 \times 10^{-3} m \cdot K \end{aligned}$$

Photoelectric Effect

$$\begin{aligned} E &= hf \\ K_{max} &= hf - \phi = e\Delta V_s \\ \lambda_c &= \frac{c}{f_c} = \frac{hc}{\phi} \end{aligned}$$

Compton Effect

$$\lambda' - \lambda_0 = \frac{h}{m_e c}(1 - \cos\theta)$$

de Broglie Wavelength

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

Uncertainty Principle

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2}$$

Atomic Physics:

Bohr's Atom

$$\begin{aligned} E_n &= -\frac{13.606eV}{n^2} \quad ; \quad n = 1, 2, 3, \ldots \\ r_n &= n^2 a_0 \quad \text{where} \quad a_0 = 0.0529nm \\ |\mathbf{L}| &= \sqrt{l(l+1)}\hbar \quad ; \quad l = 1, 2, \ldots, n-1 \\ L_z &= m_l\hbar \quad ; \quad m_l = -l, (-l+1), \ldots, l \\ |\mathbf{S}| &= \sqrt{s(s+1)}\hbar \\ S_z &= m_s\hbar = \pm\hbar/2 \end{aligned}$$

Rydberg Equation

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \quad ; \quad R_H = 1.097 \times 10^7 m^{-1}$$

Selection Rule:

$$\Delta l = \pm 1 \quad ; \quad \Delta m_l = 0, \pm 1$$

Multi-electron Atoms

$$E_n \approx -\frac{(13.606Ev)Z_{eff}^2}{n^2}$$

Nuclear Physics:

$$\begin{aligned} r &= r_0 A^{1/3} \quad ; \quad r_0 = 1.2 \times 10^{-15} m \\ E_b(MeV) &= [ZM(H) + Nm_n - M(^A_Z X)] \\ &\times \quad 931.494 MeV/u \end{aligned}$$

Radioactivity

$$\begin{aligned} N(t) &= N_0 e^{-\lambda t} \\ t_{1/2} &= \frac{\ln 2}{\lambda} = \frac{0.639}{\lambda} \\ Q &= (M_X - M_Y - M_\alpha) \times 931.494 MeV/u \end{aligned}$$

Derivatives:

$$\begin{aligned} \frac{d}{dx}\Big(\sin ax\Big) &= a\cos(ax) \\ \frac{d}{dx}\Big(\cos ax\Big) &= -a\sin(ax) \end{aligned}$$

Trigonometry:

$$\theta \ll 1 \quad rad. \rightarrow \tan\theta \approx \sin\theta \approx \theta$$

Sine Values

$$\begin{aligned} \sin 5^\circ &= 0.087 \\ \sin 10^\circ &= 0.174 \\ \sin 15^\circ &= 0.259 \\ \sin 20^\circ &= 0.342 \\ \sin 25^\circ &= 0.423 \\ \sin 30^\circ &= 0.500 \\ \sin 35^\circ &= 0.574 \\ \sin 40^\circ &= 0.643 \\ \sin 45^\circ &= 0.707 \\ \sin 50^\circ &= 0.766 \\ \sin 55^\circ &= 0.819 \\ \sin 60^\circ &= 0.866 \\ \sin 65^\circ &= 0.906 \\ \sin 70^\circ &= 0.940 \\ \sin 75^\circ &= 0.966 \\ \sin 80^\circ &= 0.984 \\ \sin 85^\circ &= 0.996 \end{aligned}$$

Cosine Values

$$\sin^2\theta + \cos^2\theta = 1$$

Units:

$$([^\circ C] = [^\circ K] - 273.15)$$

$$1 \quad eV = 1.60217646 \times 10^{-19} \quad J$$