Kinematics

$$x_f = x_i + v_{ix}t + \frac{1}{2}a_x(\Delta t)^2$$

$$x_f = x_i + \frac{1}{2}(v_{ix} + v_{fx})t$$

$$v_{fx} = v_{ix} + a_x\Delta t$$

$$v_{fx}^2 = v_{ix}^2 + 2a_x(x_f - x_i)$$

$$v_x = \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

$$a_x = \frac{\Delta v_x}{\Delta t} = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

Forces

$$f_s = \mu_s n$$

$$f_k = \mu_k n$$

$$F_{spring} = -k(x - x_0)$$

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

Momentum

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

$$\Delta p_x = J_x = F_x\Delta t$$

$$\Delta\vec{p} = 0\ (isolated\ system)$$

Energy

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

$$U_g = mg(y - y_0)$$

$$U_{spring} = \frac{1}{2}k(x - x_0)^2$$

$$\Delta E_{system} = W\ (Work)$$

$$W = F \cdot d = F\Delta x\cos\theta = F_{\parallel}d$$

Circular Motion

$$\sum F_r = \frac{mv^2}{r}$$

$$\omega = 2\pi f$$

$$T = \frac{1}{f}$$

Rotational Motion

$$s = r\theta$$

$$v = r\omega$$

$$a = r\alpha$$

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

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

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

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

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

$$\tau = rF_{\perp} = rF\sin\theta$$

$$\vec{\tau} = I\vec{\alpha}$$

$$I = \sum_i\ m_i\ r_i^2\ (point\ masses)$$

$$I = I_{CM} + md^2\ (parallel\ axis\ theorem)$$

$$\vec{L} = I\vec{\omega}$$

$$L = mvr\sin\theta$$

$$\Delta L = 0\ (isolated\ system)$$

Fluids

$$F_{buoyant} = \rho_F V g$$

$$P = F/A$$

$$P = \rho g\Delta h$$

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

Gravity

$$\vec{F}_G = -\frac{Gm_1m_2}{r^2}\hat{r}$$

Electrostatics

$$F = K\frac{q_1q_2}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}$$

$$\vec{E} = \frac{\vec{F}}{q}$$

$$\vec{E} = \frac{kQ}{r^2}\hat{r} \quad (point\ charge)$$

$$\Delta U = q\ \Delta V$$
$$U_e = K\frac{q_1 q_2}{r} \quad (\textit{point charge})$$
$$E_x = -\tfrac{dV}{dx}$$
$$F_x = -\tfrac{dU}{dx}$$
$$V = k\frac{Q}{r} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}\ (\textit{electric potential})$$
$$V_{\text{tot}} = \Sigma_i V_i$$

Current & Circuits

$$I = \frac{\Delta Q}{\Delta t}$$
$$V = I\ R$$
$$R = \rho\frac{L}{A}$$
$$P = I\ V = I^2\ R = \frac{V^2}{R}$$
$$R_{eq} = R_1 + R_2 + \cdots = \Sigma_i\ R_i\ (\textit{series})$$
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots = \Sigma_i\ \frac{1}{R_i}\ (\textit{parallel})$$
$$C_{eq} = C_1 + C_2 + \cdots = \Sigma_i\ C_i\ (\textit{parallel})$$
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots = \Sigma_i\ \frac{1}{C_i}\ (\textit{series})$$
$$Q = C\ V$$
$$C = \epsilon_0\frac{A}{d}$$
$$E_{\text{capacitor}} = \frac{\eta}{\epsilon_0} = \frac{Q}{\epsilon_0 A}$$
$$U_{capacitor} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$
$$V_C = V_0(1 - e^{-t/RC})$$

Magnetism

$$\vec{F}_{\text{on } q} = q\left(\vec{E} + \vec{v}\times\vec{B}\right)$$
$$\vec{F}_{\text{on wire}} = l\vec{I}\times\vec{B},\ |F| = IlB\ sin\theta$$
$$B_{wire} = \frac{\mu_0 I}{2\pi r}$$
$$\Phi_B = \vec{B}\cdot\vec{A} = BAcos\theta$$
$$Emf = -\frac{d\Phi_B}{dt} = -\frac{\Delta\Phi_B}{\Delta t}$$
$$\oint \vec{B}\cdot d\vec{s} = \mu_0 I\ (\textit{Ampère's Law})$$

Maxwell's Equations

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{\text{in}}}{\epsilon_0} \qquad \nabla\cdot\vec{E} = \tfrac{\rho_{in}}{\epsilon_0}$$
$$\oint \vec{B}\cdot d\vec{A} = 0 \qquad \nabla\cdot\vec{B} = 0$$
$$\oint \vec{E}\cdot d\vec{s} = -\frac{d\Phi_B}{dt} \qquad \nabla\times\vec{E} = -\tfrac{d\vec{B}}{dt}$$
$$\oint \vec{B}\cdot d\vec{s} = \mu_0 I + \mu_0\epsilon_0\frac{d\Phi_E}{dt} \qquad \nabla\times\vec{B} = \mu_0 J + \mu_0\epsilon_0\tfrac{d\vec{E}}{dt}$$

Simple Harmonic Motion & Waves

$$x(t) = A\ \cos(\omega t + \phi_0) \quad (\textit{simple harmonic motion})$$
$$D(x,t) = A\ \sin(kx - \omega t + \phi_0) \quad (\textit{traveling wave})$$
$$k = 2\pi/\lambda$$
$$\omega = 2\pi f$$
$$f = \frac{1}{T}$$
$$v = f\lambda$$
$$T = 2\pi\sqrt{\frac{L}{g}} \quad (\textit{pendulum})$$
$$T = 2\pi\sqrt{\frac{m}{k}} \quad (\textit{mass on spring})$$
$$\omega = \sqrt{\frac{k}{m}}$$
$$U_{spring} = \frac{1}{2}k(\Delta x)^2$$
$$E_{spring} = \frac{1}{2}kA^2$$
$$v_{string} = \sqrt{\frac{F_T}{\mu}}$$
$$I = \frac{P}{4\pi r^2} \quad (\textit{intensity})$$
$$L = \frac{m\lambda_m}{2} \quad (\textit{standing waves on string})$$

Sound

$v_s = (331 + 0.60\text{T})$ m/s

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

$$f' = f_0\ \left(\frac{v \pm v_o}{v \pm v_s}\right)\ \ (Doppler\ effect)$$

Geometric Optics

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

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}\ or\ \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

$$m = \frac{h^{'}}{h} = -\frac{s^{'}}{s}$$

$$n = \frac{c}{v_{medium}}$$

$$\lambda_{medium} = \lambda_{vacuum}/n$$

Light as a wave

$$d\ sin\theta_m = m\ \lambda (double\ slit,\ bright\ fringes)$$

$$a\ sin\theta_p = p\ \lambda\ (single\ slit,\ dark\ fringes)$$

$$y_m = L\tan\theta$$

$$w = \frac{2\lambda L}{a}$$

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

Special Relativity

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$\begin{cases} x' = \gamma(x - vt) \\ t' = \gamma\left(t - vx/c^2\right) \\ y' = y \\ z' = z \end{cases}$$

$$\Delta t = \gamma \Delta t_0$$

$$L = \frac{L_0}{\gamma}$$

$$p = \gamma m_0 v$$

$$m_{rel} = \gamma m_0$$

$$E_0 = m_0 c^2$$

$$KE = (\gamma - 1) m_0 c^2$$

$$E = KE + m_0 c^2 = \gamma m_0 c^2$$

$$E^2 = p^2 c^2 + m_0^2 c^4$$

$$u'_x = \frac{u_x - v}{1 - \frac{v u_x}{c^2}} \quad u'_y = \frac{u_y}{\gamma\left(1 - \frac{v u_x}{c^2}\right)} \quad u'_z = \frac{u_z}{\gamma\left(1 - \frac{v u_x}{c^2}\right)}$$

$$f = \sqrt{\frac{1+\beta}{1-\beta}} f_0\,, \quad \text{(approaching)}$$

$$f = \sqrt{\frac{1-\beta}{1+\beta}} f_0\,, \quad \text{(receding)}$$

Quantum & Atom

$$\lambda_P\ T = 2.90 \times 10^{-3}\ \text{m K}$$

$$E = nhf$$

$$E = hf$$

$$p = \frac{E}{c} = \frac{hf}{c} = \frac{h}{\lambda}$$

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

$$r_n = n^2 a_o$$

$$E_n = -13.6\ eV\ \frac{Z^2}{n^2}$$

$$\frac{1}{\lambda_m} = R\left(\frac{1}{m^2} - \frac{1}{n^2}\right)\,, \quad n > m$$

$R = 1.096776 \times 10^7 m^{-1}$ for hydrogen.
(Lyman,Balmer, Paschen for $m = 1, 2, 3$)

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

$$H\psi = i\hbar \frac{d\psi}{dt}$$

$$H = -\frac{\hbar^2}{2m}\frac{d^2\psi}{dx^2} + V\psi$$

$$E_n = n^2 \frac{\hbar^2 \pi^2}{2mL^2}\ \text{(infinite well)}$$

$$E_n = \left(n + \frac{1}{2}\right)\hbar\omega\ \text{(harmonic oscillator)}$$

$$E_n^1 = \psi^0 H^1 \psi^0\ \text{(Perturbation Energy)}$$

multiplicity of states

compton effect

Thermodynamics and Statistical Mechanics

$\Delta U = Q + W$

$Q = mc\Delta T$

$W = -P_{ext}V$

$U = NkT$

$PV = NkT$

$$\beta = \frac{\Delta V/V}{\Delta T}$$

$$S = \frac{Q}{\Delta T} = k \ln \Omega$$

$$L = \frac{Q}{m}$$

$$v_{rms} = \sqrt{\frac{3kT}{m}}$$

Classical Mechanics

$\mathcal{L} = T - U$

$$\frac{d}{dt}\left(\frac{\partial \mathcal{L}}{\partial \dot{q}_i}\right) - \frac{\partial \mathcal{L}}{\partial q_i} = 0$$

Blackbody radiation

$R = \sigma T^4\,, \quad \sigma = 5.67 \times 10^{-8} W/m^2K^4$

$\lambda_m = a/T\,, \quad a = 2.898 \times 10^{-3} m \cdot K$

$$u(\lambda) = \frac{8\pi hc\lambda^{-5}}{e^{\frac{hc}{\lambda kT}} - 1}$$

$$eV_0 = \left(\frac{1}{2}mv^2\right) = hf - \phi$$

$\lambda_2 - \lambda_1 = \dfrac{h}{mc}(1 - \cos\theta)\,, \quad$ where $\dfrac{h}{mc} =$ $0.00243\,\mathrm{nm}$

Nuclear physics

${}^{A}_{Z}X_N \rightarrow A = Z + N$

$B = ZM_Hc^2 + Nm_nc^2 - M_Ac^2$
where $M_H = 1.007825u$, $m_n = 1.008665u$.

$N(t) = N_0e^{-\lambda t}$

$$\tau = \frac{1}{\lambda}$$

$t_{1/2} = ln(2)\tau = 0.693\tau$

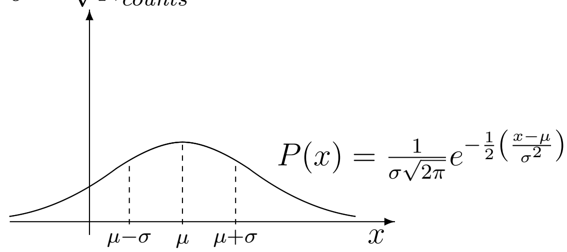
α decay: ${}^{A}_{Z>83}X_N \rightarrow {}^{A-4}_{Z-2}X_{N-2} + \alpha$.

β^- decay: ${}^{A}_{Z}X_N \rightarrow {}^{A}_{Z+1}X_{N-1} + \beta^-$.

β^+ decay: ${}^{A}_{Z}X_N \rightarrow {}^{A}_{Z-1}X_{N+1} + \beta^+$.

Statistics and Uncertainty

$\sigma = \sqrt{N_{counts}}$



Astronomy

Kepler's First Law: planets orbit in elliptical orbits

Second Law: planets sweep out equal are in equal time

Third Law: $p^2 \propto a^3$

Hubble's Law: $v_{recession} = H_0d$

Miscellaneous

orthogonal vectors: $\vec{A} \cdot \vec{B} = 0$