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

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

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

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

$\vec{X}_{\text{CM}} = \frac{1}{M}\sum m_i\vec{x}_i\ \left(M = \sum m_i\right)$

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

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

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

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

$$\Delta U = q\ \Delta V$$

$$U_e = K\frac{q_1 q_2}{r} \quad (point\ charge)$$

$$E_x = -\tfrac{dV}{dx}$$

$$F_x = -\tfrac{dU}{dx}$$

$$V = k\frac{Q}{r} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r}\ (electric\ potential)$$

$$V_{\text{tot}} = \Sigma_i V_i$$

Current & Circuits

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

$$V = I\ R$$

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

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

$$R_{eq} = R_1 + R_2 + \cdots = \Sigma_i\ R_i\ (series)$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots = \Sigma_i\ \frac{1}{R_i}\ (parallel)$$

$$C_{eq} = C_1 + C_2 + \cdots = \Sigma_i\ C_i\ (parallel)$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots = \Sigma_i\ \frac{1}{C_i}\ (series)$$

$$Q = C\ V$$

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

$$E_{\text{capacitor}} = \frac{\eta}{\epsilon_0} = \frac{Q}{\epsilon_0 A}$$

$$U_{capacitor} = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$V_C = V_0(1 - e^{-t/RC})$$

Magnetism

$$\vec{F}_{\text{on }q} = q\left(\vec{E} + \vec{v}\times\vec{B}\right)$$

$$\vec{F}_{\text{on wire}} = l\vec{I}\times\vec{B},\ |F| = IlB\ sin\theta$$

$$B_{wire} = \frac{\mu_0 I}{2\pi r}$$

$$\Phi_B = \vec{B}\cdot\vec{A} = BAcos\theta$$

$$Emf = -\frac{d\Phi_B}{dt} = -\frac{\Delta\Phi_B}{\Delta t}$$

$$\oint \vec{B}\cdot d\vec{s} = \mu_0 I\ (Amp\grave{e}re\text{'s } Law)$$

Maxwell's Equations

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

Simple Harmonic Motion & Waves

$$x(t) = A\ \cos(\omega t + \phi_0) \quad (simple\ harmonic\ motion)$$

$$D(x,t) = A\ \sin(kx - \omega t + \phi_0) \quad (traveling\ wave)$$

$$k = 2\pi/\lambda$$

$$\omega = 2\pi f$$

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

$$v = f\lambda$$

$$T = 2\pi\sqrt{\frac{L}{g}} \quad (pendulum)$$

$$T = 2\pi\sqrt{\frac{m}{k}} \quad (mass\ on\ spring)$$

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

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

$$E_{spring} = \frac{1}{2}kA^2$$

$$v_{string} = \sqrt{\frac{F_T}{\mu}}$$

$$I = \frac{P}{4\pi r^2} \quad (intensity)$$

$$L = \frac{m\lambda_m}{2} \quad (standing\ waves\ on\ string)$$

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

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

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

$\Delta t = \gamma \Delta t_0$

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

$p = \gamma m_0 v$

$m_{rel} = \gamma m_0$

$E_0 = m_0 c^2$

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

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

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

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

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

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

Quantum & Atom

$\lambda_P\ T = 2.90 \times 10^{-3}$ 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 $m = 1, 2, 3$)

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

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

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

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

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

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

multiplicity of states

compton effect

Thermodynamics and Statistical Mechanics

$\Delta U = Q + W$

$Q = mc\Delta T$

$W = -\int PdV$

$U = NkT$

$PV = NkT$

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

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

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

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

Adiabatic: no heat exchanged
Isothermal: constant temperature
Isobaric: constant pressure

Classical Mechanics

$\mathcal{L}(q, \dot{q}, t) = T - U$

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

$\mathcal{H}(q, p) = T + U$ (for a conservative potential)

$\dot{p} = -\dfrac{\partial \mathcal{H}}{\partial q} \qquad \dot{q} = +\dfrac{\partial \mathcal{H}}{\partial p}$

Blackbody radiation

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

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

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

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

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

Nuclear physics

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

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

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

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

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

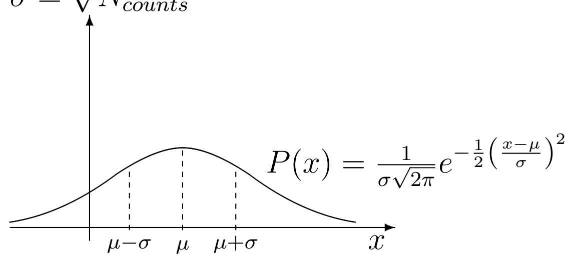
α decay: ${}^{A}_{Z>83}X_N \rightarrow {}^{A-4}_{Z-2}X_{N-2} + \alpha$.

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