

Relativity

Time dilation: $T_{\text{obs}} = \gamma \cdot T_0$

Length contraction: $L_{\text{obs}} = L_0/\gamma$

Relativistic Doppler Shift: $f_{\text{obs}} = \frac{\sqrt{1 + (v/c)}}{\sqrt{1 - (v/c)}} f_{\text{source}}$ (for approaching source)

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

$$\text{Lorentz velocity transformations: } \begin{cases} u'_x = \frac{u_x - v}{1 - (u_x v/c^2)} \\ u'_y = \frac{u_y}{\gamma[1 - (u_x v/c^2)]} \\ u'_z = \frac{u_z}{\gamma[1 - (u_x v/c^2)]} \end{cases}$$

Relativistic momentum: $\mathbf{p} = \gamma m \mathbf{u}$

Relativistic Energy: $E = \gamma mc^2$

Energy-momentum relation: $E^2 = p^2 c^2 + (mc^2)^2$

Binding Energy: $BE = \sum_{i=1}^n m_i c^2 - Mc^2$

Stefan's law: $e_{\text{total}} = \sigma T^4$, $\sigma = 5.67 \cdot 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Planck's law: $u(f, T) = \frac{8\pi hf^3}{c^3} \left(\frac{1}{e^{hf/k_B T} - 1} \right)$

Wien's Displacement Law: $\lambda_{\text{max}} T = 2.898 \cdot 10^{-3} \text{ m K}$

Photoelectric effect: $K_{\text{max}} = hf - \Phi$

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

Bohr's atom: $r_n = \frac{n^2 \hbar^2}{m_e k e^2}$
 $E_n = -\frac{k e^2}{2a_0} \left(\frac{1}{n^2} \right)$, $a_0 = 0.0529 \text{ nm}$

Heisenberg uncertainty principle: $\Delta x \cdot \Delta p_x \geq \frac{\hbar}{2}$
 $\Delta E \cdot \Delta t \geq \frac{\hbar}{2}$

Schrödinger equation: $-\frac{\hbar^2}{2m} \frac{\partial^2 \Psi(x, t)}{\partial x^2} + U(x, t) \cdot \Psi(x, t) = i\hbar \frac{\partial \Psi(x, t)}{\partial t}$

Particle in a box: $E_n = \frac{n^2 \pi^2 \hbar^2}{2mL^2}$

Operators:

Position: $[x] = x$

Momentum: $[p] = \frac{\hbar}{i} \frac{\partial}{\partial x}$

Hamiltonian: $[H] = -\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2} + U(x, t)$

Transmission of a tall, wide barrier: $T(E) \approx \exp\left(-\frac{2}{\hbar} \sqrt{2m} \int_{x_1}^{x_2} \sqrt{U(x) - E} \cdot dx\right)$