

Useful Formulae:

Rayleigh-Jean's Law:	Intensity = $(8\pi v^2/c^3) kT$
Planck Radiation Law:	$8\pi h v^3/kT * (\exp(hv/kT)-1)^{-1}$
Wein's Law:	$\lambda_{\max} T = 2.897 * 10^{-3} \text{ mK}$
Stefan's Law:	$W = \sigma T^4$
Balmer Formula:	$\lambda = 364.6 n^2 / (n^2-4)$
Grating Formula:	$d \sin \theta = m \lambda$
Bohr Radii:	$r = n^2 a_0$
Hydrogen Energy:	$E = -13.6 / n^2$
Mode Spacing:	$\Delta v = c/2L$
Rate equations:	$r = dN/dt = W N$
Pumping probability:	$W = \sigma I/hv$
Level lifetime:	$\tau = 1/(\Sigma A)$
Gain coefficient:	$g = (N_2 - N_1) \sigma_0$
Minimum pump energy:	$P_{\text{minimum}} = dN_{\text{ULL}}/dt V h v_{\text{mp}}$
Differential solution:	$dN_{\text{ULL}}/dt = -1/\tau N_{\text{ULL}}$

Laser Rate Equations:	$r_{\text{absorption}} = B_{12} N_1 \rho$
	$r_{\text{stimulated}} = B_{21} N_2 \rho$
	$r_{\text{spontaneous}} = A_{21} N_2$
	$A_{21} = 1/\tau_{21}$
	$r_{\text{stimulated}} / r_{\text{spontaneous}} = c^3 \rho / 8\pi h v^3$
	$r_{\text{stimulated}} / r_{\text{absorption}} = N_2 / N_1$

Planck's Relationship:	$E = h v = \frac{hc}{\lambda}$	Boltzmann's Law:	$N = N_0 e^{\frac{-E}{kT}}$
Cavity Radiation:	$\rho = \frac{8\pi h v^3}{c^3} \frac{1}{e^{\frac{E}{kT}} - 1}$	Saturation Intensity:	$I_{\text{sat}} = \frac{h v}{\sigma_0 \tau}$
Fresnel equation: (at 90 degrees)	$R = \left(\frac{n_1 - n_2}{n_1 + n_2} \right)^2$	Fresnel equation:	$R_p = \left(\frac{n \cos \theta_i - \cos \theta_r}{n \cos \theta_i + \cos \theta_r} \right)^2$
Linewidth:	$\Delta v = 2v_0 \sqrt{\frac{2kT \ln(2)}{Mc^2}}$	Snell's Law:	$\frac{\sin \theta_i}{n_r} = \frac{\sin \theta_r}{n_i}$
Threshold Gain: (simple configuration)	$g_{\text{threshold}} = \gamma + \frac{1}{2x} \ln\left(\frac{1}{R_1 R_2}\right)$	Saturated Gain:	$g_{\text{sat}} = \frac{g_0}{1 + \frac{\rho}{\rho_{\text{sat}}}}$

Constants and Conversions:

1eV = 1.602E⁻¹⁹J

k = Boltzmann's constant (1.38 * 10⁻²³ J/K)

σ = Stefan-Boltzmann constant (5.67 * 10⁻⁸ Wm⁻²K⁻⁴)

a_0 = Bohr radius (5.29 * 10⁻¹¹ m)

1 mole (Avogadro's number) = 6.02 * 10²³ atoms/molecules

Indices of Refraction: Quartz = 1.46, Glass = 1.51

Atomic masses: Neon = 20 amu, Argon = 38 amu, Helium = 4 amu, Cadmium=112 amu, CO₂ = 44 amu

0 C = 273.15 K

h = Planck's constant (6.626 * 10⁻³⁴ Js)

c = Speed of Light (3 * 10⁸ m/s)