Prefixes

a=10^{-18}, f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}

Physical Constants

$k = 1/4\pi\epsilon_0 = 8.988$ GNm^2/C^2 (Coulomb's Law)
$e = 1.602 \times 10^{-19}$ C (proton charge)
$m_e = 9.11 \times 10^{-31}$ kg (electron mass)
$c = 3.00 \times 10^8$ m/s (speed of light)
$h = 6.62607 \times 10^{-34}$ J·s (Planck's constant)
$\sigma = 5.67 \times 10^{-8}$ W/(m^2·K^4) (Stefan-Boltzmann const.)

$\epsilon_0 = 1/4\pi k = 8.854$ pF/m (permittivity of space)
$\mu_0 = 4\pi \times 10^{-7}$ T·m/A (permeability of space)
$m_p = 1.67 \times 10^{-27}$ kg (proton mass)
$c = 2.99792458 \times 10^8$ m/s (exact value in vacuum)
$\hbar = 1.05457 \times 10^{-34}$ J·s (Planck's constant/2π)
hc =1239.84 eV·nm (photon energy constant)

Units

$N_A = 6.02 \times 10^{23}$/mole (Avogadro's #)
1.0 eV = 1.602×10^{-19} J (electron-volt)
1 F = 1 C/V = 1 farad = 1 C^2/J
1 A = 1 C/s = 1 ampere = 1 coulomb/second
1 T = 1 N/A·m = 1 tesla = 1 newton/ampere·meter

1 u = 1 g/N_A = 1.6605×10^{-27} kg (mass unit)
1 V = 1 J/C = 1 volt = 1 joule/coulomb
1 H = 1 V·s/A = 1 henry = 1 J/A^2
1 Ω = 1 V/A = 1 ohm = 1 J·s/C^2
1 G = 10^{-4} T = 1 gauss = 10^{-4} tesla

OpenStax Chapter 24 Equations - Electromagnetic Waves

Electromagnetic waves:

$|\vec{E}|/|\vec{B}| = c = 1/\sqrt{\epsilon_0\mu_0}$, (fields and speed) $f\lambda = c$ (wave equation)

Energy density, intensity, power:

$u = \epsilon_0 E^2 = \frac{B^2}{\mu_0}$ (instantaneous energy density) $\overline{u} = \frac{1}{2}\epsilon_0 E_0^2 = \frac{B_0^2}{2\mu_0}$ (average energy density)

$I = \overline{u}c = \frac{1}{2}\epsilon_0 E_0^2 c$ (EM waves intensity) $I = P/A = P/(4\pi r^2)$ (intensity definition)

Approximate wavelengths λ for types of EM waves:

0 (γ-rays) 30 pm (x-rays) 3 nm (uv) 400 nm (visible) 700 nm (ir) 300 μm (μ-waves) 3 cm (radio) ∞

$\longrightarrow$ $\longrightarrow$ $\longrightarrow$ increasing wavelength $\longrightarrow$ $\longrightarrow$ $\longrightarrow$

OpenStax Chapter 27 Equations - Wave Optics

Wave properties, interference:

$\lambda_n = \lambda_{\text{vacuum}}/n$ (wavelength in a medium) $\Delta x = d\sin\theta$ (path difference in double slits)

$d\sin\theta = m\lambda$ (double slits bright fringes) $d\sin\theta = (m + 1/2)\lambda$ (double slits dark fringes)

Diffraction:

$D\sin\theta = m\lambda$ (single slit minima) $y = L\tan\theta$ (position on a screen)

$d\sin\theta = m\lambda$ (diffraction grating maxima) $d = 1/$(lines per meter).

Rayleigh's Diffraction Limit:

$\theta_{\text{min}} = 1.22\lambda/D$ (resolution limit) $\theta = s/r$ (angular separation in radians)

Polarization:

$I = I_0\cos^2\theta$ (transmission thru polarizer) $I = \frac{1}{2}I_0$ (transmission of unpolarized light)

OpenStax Chapter 28 Equations - Special Relativity

Time dilation and length contraction:

$\Delta t = \gamma \Delta t_0 = \Delta t_0 / \sqrt{1 - v^2/c^2}$

$L = L_0/\gamma = L_0 \sqrt{1 - v^2/c^2}$

$\gamma = 1/\sqrt{1 - v^2/c^2}$ (relativistic factor)

$v/c = \sqrt{1 - 1/\gamma^2}$ (velocity)

Dyanmics, mass, energy:

$p = \gamma m_0 v$ (relativistic momentum)

$m_{\text{rel}} = \gamma m_0$ (relativistic mass)

$E_0 = m_0 c^2$ (rest energy)

$E = \gamma m_0 c^2 = m_{\text{rel}} c^2$ (relativistic energy)

$\text{KE} = E - E_0 = (\gamma - 1) m_0 c^2$ (kinetic energy)

$E = E_0 + \text{KE} = \sqrt{p^2c^2 + m^2c^4}$ (relativistic energy)

OpenStax Chapter 29 Equations - Quanta and Quantum Waves

Blackbody radiation, photons, photo-electric effect:

$\lambda_p T = 2.90$ mm·K (Wien's Law)

$I = \sigma T^4$ (intensity or power/area)

$E = nhf,\ n = 1, 2, 3...$ (quantized radiation energy)

$E = hc/\lambda = (1240 \text{ eV} \cdot \text{nm})/\lambda$ (photons)

$E = hf = W_0 + \text{KE}_{\text{max}}$ (photo-electrons)

$hc/\lambda_{\text{max}} = W_0$ (work function)

$\text{KE}_{\text{max}} = eV_0$ (stopping potential)

$v_{\text{max}} = \sqrt{2\text{KE}_{\text{max}}/m}$ (max. speed)

Momentum, matter waves:

$p = h/\lambda$ (quantum momentum)

$\lambda' = \lambda + \frac{h}{mc}(1 - \cos\phi)$ (Compton effect)

$\lambda = h/p$ (de Broglie wavelength)

KE$= p^2/2m$ (kinetic energy, $v \ll c$)

$\Delta\text{KE} + q\Delta V = 0$ (acceleration thru potential)

$v = \sqrt{2q\Delta V/m}$ (acceleration thru potential, $v \ll c$)

Heisenberg Uncertainty Principle:

$\Delta x\ \Delta p_x \geq \hbar/2$ (uncertainty principle)

$\hbar = \frac{h}{2\pi} = 1.05459 \times 10^{-34}$ J·s

$\Delta E\ \Delta t \geq \hbar/2$ (energy-time form)

($\leftarrow$ These are approximate relations.)

$\Delta E = \Delta m \cdot c^2$ (Einstein's mass-energy equivalence)

($\leftarrow$ This one is exact.)