Maxwell's Equations (Guassian)

Electrodynamics

Maxwell's Equations (SI)

Electrodynamics

Gaussian Integrals

General Math

Stirling's Approximation

General Math

Adiabatic Process

Thermodynamics

Adiabatic Properties of Ideal Gas

Thermodynamics

Bose-Einstein Distribution

Thermodynamics

Carnot Efficiency

Thermodynamics

Carnot Cycle

Thermodynamics

Equipartition Theorem

Thermodynamics

$$\vec{\nabla} \cdot \vec{D} = \rho_f \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + \vec{J}_f$$

$$\vec{\nabla} \cdot \vec{D} = 4\pi\rho_f \qquad \vec{\nabla} \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{H} = \frac{1}{c}\left(\frac{\partial \vec{D}}{\partial t} + 4\pi\vec{J}_f\right)$$

$$n! \approx \left(\frac{n}{e}\right)^n \sqrt{2\pi n}$$

$$\ln n! \approx n \ln n - n$$

$$I_n(x) = \int_0^\infty x^n e^{-ax^2}\, dx = \begin{cases} \frac{1}{2}\sqrt{\frac{\pi}{a^{m+1}}}\frac{(2m)!}{4^m m!} & n = 2m \\ \frac{1}{2}\frac{1}{a^{k+1}}k! & n = 2k+1 \end{cases}$$

$$I_0(x) = \frac{1}{2}\sqrt{\frac{\pi}{a}} \qquad I_1(x) = \frac{1}{2a}$$

$$I_2(x) = \frac{1}{4a}\sqrt{\frac{\pi}{a}} \qquad I_3(x) = \frac{1}{2a^2}$$

$$\begin{aligned} T_1 {V_1}^{\gamma-1} &= \text{const} \\ {T_1}^{\gamma/(1-\gamma)} P_1 &= \text{const} \\ P_1 {V_1}^{\gamma} &= \text{const} \end{aligned}$$

Also called *isentropic*. $\Delta S = 0$ in the process. Use the thermodynamic identity at constant volume and a systems internal energy equation to derive properties about the entropy of the system.

$$\eta = 1 - \frac{T_l}{T_h}$$

$$f(\varepsilon) = \frac{1}{e^{(\varepsilon-\mu)/k_B T} - 1}$$

A classical gas's energy gains $\frac{1}{2}k_B T$ for each degree of freedom. An ideal monotomic gas has $U = \frac{3}{2}k_B T$ from three translational degrees of freedom, while an ideal diatomic gas has $U = \frac{5}{2}k_B T$ from an additional two degrees of rotational freedom.

Characterized by alternating stages of isothermal and isentropic expansion and compression. Work done is

$$W = (T_h - T_l)(S_H - S_L)$$

where T_l and T_h are the low and high temperatures reached during the cycle and S_L and S_H are the low and high entropies of the working substance.

Fermi Gasses

THERMODYNAMICS

Fermi-Dirac Distribution

THERMODYNAMICS

Gibbs Free Energy

THERMODYNAMICS

Helmholtz Free Energy

THERMODYNAMICS

Ideal Gasses

THERMODYNAMICS

Ideal Gas (RMS Average Speed)

THERMODYNAMICS

Ideal Monoatomic Gas

THERMODYNAMICS

Maxwell Speed Distribution

THERMODYNAMICS

Partition Function

THERMODYNAMICS

Photon Gasses

THERMODYNAMICS

$$f(\varepsilon) = \frac{1}{e^{(\varepsilon-\mu)/k_B T} + 1}$$

1. High kinetic energy
2. Low heat capacity
3. Low magnetic susceptibility
4. Low interparticle collision rate
5. High pressure

Acts as effective energy in isothermal changes of volume.

$$F \equiv U - TS$$

$$dF = dU - SdT$$

$$G \equiv U + PV - TS$$

Derived by considering a single particle. For translation in three dimensions $KE = \frac{3}{2}k_B T$ and also $KE = \frac{1}{2}mv^2$ so that when combined,

$$\frac{1}{2}mv^2 = \frac{3}{2}k_B T$$

$$v = \sqrt{\frac{3k_B T}{m}}$$

$$PV = nRT$$

$$PV = Nk_B T$$

$$Z_N = \frac{Z_1^N}{N!}$$

$$f(v) = \sqrt{\left(\frac{m}{2\pi k_B T}\right)^3} 4\pi v^2 \exp\left(-\frac{mv^2}{2k_B T}\right)$$

$$v_{\text{rms}} = \sqrt{\frac{3k_B T}{m}} \qquad \langle v \rangle = \sqrt{\frac{8k_B T}{\pi m}}$$

$$C_V = \frac{3}{2}Nk_B \qquad C_P = \frac{5}{2}Nk_B$$

$$U = \frac{3}{2}Nk_B T \qquad \gamma = \frac{5}{3}$$

$$U = \sigma_b V T^4$$

$$P = \frac{1}{3}\sigma_b V T^4$$

$$\mu = 0$$

$$Z = \sum_n e^{-\varepsilon_n/k_B T}$$

$$U = k_B T^2 \frac{\partial \ln Z}{\partial T} \qquad F = -k_B T \ln Z$$

Planck Distribution function

Thermodynamics

Planck Spectral Density (frequency)

Thermodynamics

Radiant Energy Flux (blackbody)

Thermodynamics

Stefan-Boltzmann Law (energy density)

Thermodynamics

Thermodynamic Identity

Thermodynamics

$$u_\omega = \frac{\hbar}{\pi^2 c^3} \frac{\omega^3}{e^{\hbar\omega/k_B T} - 1}$$

$$\langle s \rangle = \frac{1}{e^{\hbar\omega/k_B T} - 1}$$

$$\frac{U}{V} = u = \frac{\pi^2 {k_B}^3}{15\hbar^3 c^3} T^4$$

$$u = \sigma_B T^4$$

$$u = \frac{4}{c} J_u$$

$$J_u = \frac{\pi^2 {k_B}^4}{60\hbar^3 c^2} T^4$$

$$J_u = \frac{c}{4} u$$

$$dU = T\,dS - P\,dV + \mu\,dN$$

$$C_V = \left(\frac{\partial U}{\partial T}\right)_V = T\left(\frac{\partial S}{\partial T}\right)_V \qquad P = -\left(\frac{\partial U}{\partial V}\right)_S$$