PHYS252 General Physics: Formula

Part 1. Mechanics

Kinematics:

$\vec{r}$, Velocity $\vec{v} = \frac{d\vec{r}}{dt}$ Acceleration $\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$

Constant Acceleration Kinematics

$\vec{v} = \vec{v}_0 + \vec{a}t$ $\vec{r} = \vec{r}_0 + \vec{v}_0 t + \frac{1}{2}\vec{a}t^2 = \vec{r}_0 + \frac{1}{2}(\vec{v}_0 + \vec{v})t$ $x = x_0 + \frac{1}{2a}(v^2 - v_0^2)$

Dynamics, Friction & Gravity

$$\frac{\vec{F}_{\text{net}}}{m} = \vec{a}\ ;\ \vec{F}_{AB} = -\vec{F}_{BA}\ ;\ |f_s| \le \mu_s N\ ;\ |f_k| = \mu_k N\ ;\ F^{\text{spring}} = -kx\ ;\ \vec{F}^{\text{grav}}_{ab} = -\frac{Gm_a m_b}{r^2_{ab}}\hat{r}_{ab}\ ;\ F^{\text{grav}}_{\text{earth,m}} = w = gm$$

Work, Energy & Momentum

$$W_{\text{by}\vec{F}} = \int \vec{F}\cdot d\vec{s} = \int F_x dx + \int F_y dy + \int F_z dz\ ;\ K = \frac{1}{2}mv^2\ ;\ \Delta U = -W_{\text{BCF}}\ ;\ F_{\text{int,cons}} = -\frac{dU}{dx}$$

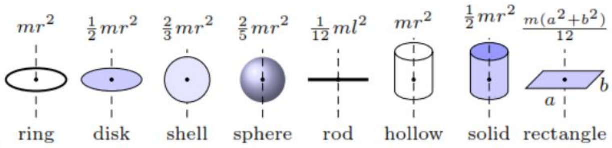
$$U_{\text{g}} = -\frac{GMm}{r}\ ;\ U_{\text{g}} = mgy\ ;\ U_{\text{sp}} = \frac{1}{2}kx^2\ ;\ W_{\text{ext}} = \Delta E_{\text{sys}} = \Delta K + \Delta U_{\text{g}} + \Delta U_{\text{sp}} + \Delta E_{\text{chem}} + \Delta E_{\text{therm}}\ ;\ f\Delta s = \Delta E_{\text{therm}}$$

$$P \equiv \frac{dW}{dt} = \vec{F}\cdot\vec{v}\ ;\ v_{2f} - v_{1f} = -(v_{2i} - v_{1i})\ ;\ \vec{p} = m\vec{v}\ ;\ \vec{I} = \int \vec{F}dt = \Delta\vec{p}\ ;\ \sum F_{\text{ext}} = \frac{d\vec{P}}{dt}$$

Systems of Particles

$$\vec{r}_{\text{cm}} = \frac{1}{M_{\text{tot}}}\sum m_i\vec{r}_i\quad ;\quad \vec{r}_{\text{cm}} = \frac{\int \vec{r}dm}{\int dm}$$

Moment of Inertia:



Rotational Dynamics

$$I = \sum m_i r_i^2\ ;\ I = \int r^2 dm\ ;\ I_{\text{p}} = I_{\text{cm}} + Mh^2\ ;\ K = \frac{1}{2}I\omega^2\ ;\ W_{\text{rot}} = \int \tau d\theta = \Delta K_{\text{rot}}\ ;\ P = \frac{dW}{dt} = \tau\omega\ ;\ \vec{L} = \vec{r}\times\vec{p}$$

$$\vec{\tau} = \vec{r}\times\vec{F}\ ;\ \tau = r_\perp F\ ;\ \sum\vec{\tau} = I\vec{\alpha}\ ;\ \sum\vec{\tau} = \frac{d\vec{L}}{dt}\ ;\ v_{\text{cm}} = r\omega\ ;\ a_{\text{cm}} = r\alpha\ ;\ \vec{L} = I\vec{\omega}$$

Part 2. Thermo physics and Thermodynamics

Ideal Gas Law (Equation of State): $pV = nRT$ *Number of moles:* $n = \frac{M}{\mu} = \frac{N}{N_A}$

Molecular Energy

Average Kinetic Energy of a molecule of an Ideal Gas : $KE_{avg} = \frac{i}{2}kT$ where i is the degree of freedom

Internal Energy a gas system: $U = N.KE_{avg} = \frac{M}{\mu}.\frac{i}{2}RT$ in a process, change of U is: $\Delta U = \frac{M}{\mu}.\frac{i}{2}R\Delta T$

Maxwell-Boltzmann Distribution and Molecular Speeds

Maxwell Distribution Formula: $f(v) = 4\pi\left(\frac{m}{2\pi kT}\right)^{3/2} v^2 e^{-\frac{mv^2}{2kT}}$ Most Probable Speed: $v_{mp} = \sqrt{\frac{2k_BT}{m}} = \sqrt{\frac{2RT}{\mu}}$

Average Speed: $v_{avg} = \sqrt{\frac{8k_BT}{\pi m}} = \sqrt{\frac{8RT}{\pi\mu}}$ Root Mean Square Speed: $v_{r.m.s} = \sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{3RT}{\mu}}$

Boltzmann Distribution Law: High-dependence of pressure in the atmosphere $P(z) = P(0)e^{-\frac{mg}{k_BT}z} = P(0)e^{-\frac{\mu g}{RT}z}$

Distribution of Particles in the atmosphere: $n_0(z) = n_0 e^{-\frac{mg}{k_BT}z} = n_0 e^{-\frac{\mu g}{RT}z}$

First Law of Thermodynamics: ΔU =W + Q *(Work done on the gas + heat gained)*

Consequence of the First Law: ΔU = 0 for an isolated system; (for a closed cycle: ΔU = 0 W = –Q =Q'; or Q = –W=W'

Isochoric Process (V = const); => Equation: $\frac{T}{p} = const \Rightarrow \frac{p_1}{T_1} = \frac{p_2}{T_2}$; Work done: W = 0; Heat Received: $Q = \frac{M}{\mu}C_v\Delta T$

Isobaric Process (p=const)=> equation $\frac{V}{T} = const \Rightarrow \frac{V_1}{T_1} = \frac{V_2}{T_2}$; Work done by gas: W'= p(V_2–V_1); Heat Received: $Q = \frac{M}{\mu}C_p\Delta T$

Isothermal Process (T = const) PV = const; ΔU = 0 because ΔT = 0. Work done by gas= Heat Received: $W' = Q = \frac{M}{\mu}.RT.\ln\frac{V_2}{V_1}$

Adiabatic Process (Q = 0, dQ=0) Work done on gas: $W = \Delta U = \frac{M}{\mu}.\frac{i}{2}R\Delta T$; State Equations: $PV^\gamma = const$; or $TV^{\gamma-1} = const$

Entropy and the Second Law of Thermodynamics : Defination of Entropy $\Delta S = \int\frac{\delta Q}{T}$ of reversible processes

Second Law Expression: $\sum\frac{Q_i}{T_i} \le 0$ (equal for reversible processes); For a close/isolated system: $dS \ge 0$

Change of Entropy of an Ideal Gas through an equillibrium process :

Entropy in a Reversible Process: $\Delta S = \frac{m}{\mu}C_v\ln\frac{T_2}{T_1} + \frac{m}{\mu}R\ln\frac{V_2}{V_1} = \frac{m}{\mu}C_v\ln\frac{p_2}{p_1} + \frac{m}{\mu}C_p\ln\frac{V_2}{V_1}$

Isochoric Process: $\Delta S = \frac{m}{\mu}C_v\ln\frac{p_2}{p_1}$ Isobaric Process: $\Delta S = \frac{m}{\mu}C_p\ln\frac{V_2}{V_1}$

Efficiency of a heat engine: $e = \frac{W'}{Q_{hot}} = 1 - \frac{Q'_{cold}}{Q_{hot}}$ Carnot Engine: $e_c = 1 - \frac{T_{cold}}{T_{hot}}$