Official Starting Equations (OSEs) for Engineering Physics 1 (Physics 1135)

Component versions of vector OSEs are also OSEs.

Kinematics: $\vec{r} = x\hat{\imath} + y\hat{\jmath}$ $\quad \vec{v} = \frac{d\vec{r}}{dt}$ $\quad \vec{a} = \frac{d\vec{v}}{dt}$

Constant $\vec{a}$: $x = x_0 + v_{0x}t + \frac{1}{2}\,a_x t^2$ $\quad v_x = v_{0x} + \,a_x t$ $\quad {v_x}^2 = {v_{0x}}^2 + 2\,a_x(x - x_0)$

$y = y_0 + v_{0y}t + \frac{1}{2}\,a_y t^2$ $\quad v_y = v_{0y} + \,a_y t$ $\quad {v_y}^2 = {v_{0y}}^2 + 2\,a_y(y - y_0)$

Newton's Laws: $\Sigma\vec{F} = m\vec{a}$ $\quad \sum F_x = ma_x$ $\quad \sum F_y = ma_y$ $\quad \vec{F}_{BA} = -\vec{F}_{AB}$

Weight: $\overrightarrow{W} = (mg, down) = -mg\hat{\jmath}$ if $y-$axis is up

Spring force: $F_{S,x} = -kx$

Friction: $f_S \leq \mu_S N$ $\quad f_k = \mu_k N$

Circular motion: $a_c = \frac{v^2}{R}$

Dot Product: $\vec{A}\cdot\vec{B} = ABcos\theta_{AB} = AB_{||A} = A_{||B}B = A_xB_x + A_yB_y + A_zB_z$

Work: $W = \int_i^f \vec{F}\cdot d\vec{r}$ $\quad \vec{F}$ =constant $\Longrightarrow W = \vec{F}\cdot\vec{D}$ **Power:** $P = \frac{dW}{dt}$ $\quad P = \vec{F}\cdot\vec{v}$

Work-KE: $K = \frac{1}{2}mv^2$ $\quad \Delta K = W_{net}$

Mechanical Energy: $E = K + U$ $\quad E_f - E_i = W_{other}$

Potential Energy: $U_f - U_i = -W_{i\to f}$ $\quad U_{grav} = mgy$ (near surface, y-axis up) $\quad U_{spring} = \frac{1}{2}kx^2$

$F_x = -\frac{\partial U}{\partial x}$

Universal Gravitation: $F_G = \frac{GmM}{r^2}$ $\quad U_G = -\frac{GmM}{r}$

Momentum: $\vec{p} = m\vec{v}$ $\quad \vec{F}_{net} = \frac{d\vec{p}}{dt}$

Impulse: $\vec{J} = \int \vec{F}\,dt$ $\quad \vec{p}_f - \vec{p}_i = \vec{J}_{net}$

System: $\vec{P} = \sum \vec{p}_n$ $\quad \vec{P}_f - \vec{P}_i = \vec{J}_{net\;ext}$

Center of mass: $M_{tot}\vec{R}_{CM} = \sum m_n\vec{r}_n$ $\quad M_{tot}\vec{a}_{CM} = \sum m_n\vec{a}_n = \sum \vec{F}_{ext}$

Angular kinematics: $\omega_z = \frac{d\theta}{dt}$ $\quad \alpha_z = \frac{d\omega_z}{dt}$ $\quad v_{tan} = \omega R$ $\quad a_{tan} = \alpha R$ $\quad a_{rad} = R\omega^2$

Constant α_z: $\theta = \theta_0 + \omega_{0z}t + \frac{1}{2}\,\alpha_z t^2$ $\quad \omega_z = \omega_{0z} + \,\alpha_z t$ $\quad {\omega_z}^2 = {\omega_{0z}}^2 + 2\,\alpha_z(\theta - \theta_0)$

Rotational KE: $K_{rot} = \frac{1}{2}I\omega^2$ $\quad$ **Rolling:** $v_{CM} = \omega_{CM}R$

Moment of inertia: $I = \sum_i m_i r_i^2$ $\quad I_P = I_{CM} + Md^2$

Cross product: $\vec{A} \times \vec{B} = (ABsin\theta_{AB}, direction\ by\ right\ hand\ rule)$

Torque: $\vec{\tau} = \vec{r} \times \vec{F}$ $\quad \tau = rF_\perp = r_\perp F = rF\ sin\theta$ $\quad \sum \tau_z = I\alpha_z$

Angular momentum: Particle: $\vec{l} = \vec{r} \times \vec{p}$ $\quad l = rp_\perp = r_\perp p = rp\ sin\theta$ $\quad$ Rigid rotation: $\vec{L} = I\vec{\omega}$

System: $\sum \vec{\tau}_{ext} = \frac{d\vec{L}}{dt}$ $\quad \vec{L}_i = \vec{L}_f\ if\ \sum \vec{\tau}_{ext} = 0$

Fluids: $p = p_o + \rho gh$ $\quad B = \rho_{fl} g V_{disp}$

SHO: $a_x(t) = \frac{d^2x}{dt^2} = -\omega^2 x(t)$ $\quad x(t) = A\cos(\omega t + \varphi)$ $\quad \omega = 2\pi f = \frac{2\pi}{T}$

Mass-spring: $\omega = \sqrt{\frac{k}{m}}$ $\quad$ Simple pendulum: $T = 2\pi\sqrt{\frac{L}{g}}$ $\quad$ Physical pendulum: $T = 2\pi\sqrt{\frac{I}{mgd}}$

Traveling waves: $y = A\sin(kx \pm \omega t + \varphi)$ $\quad k = \frac{2\pi}{\lambda}$ $\quad v = f\lambda = \frac{\omega}{k}$ $\quad$ String: $v = \sqrt{\frac{T}{\mu}}$

Standing wave: $y = 2A\sin(kx)\cos(\omega t)$ $\quad$ **Interference:** $\Delta L_{const} = n\lambda$ $\quad \Delta L_{dest} = (n + \frac{1}{2})\lambda$

Doppler: $f'_o = f_S \frac{v - v_{ox}}{v - v_{sx}}$ $\quad x - axis\ S \rightarrow O$

Heating Processes: $Q = mc\Delta T = nC\Delta T$ $\quad Q_{phase\ change} = mL_{phase\ change}$

Heat Transfer: $H = \frac{dQ}{dt}$ $\quad H = kA(T_H - T_C)/L$

Ideal Gas: $pV = nRT$ $\quad c_v = \frac{3}{2}R, c_p = \frac{5}{2}R\ (monoatomic)$ $\quad c_v = \frac{5}{2}R, c_p = \frac{7}{2}R\ (diatomic)$

$\Delta U = nc_v\Delta T$ $\quad adiabatic: pV^\gamma = const, \gamma = c_p/c_V$

Thermo: $\Delta U = Q - W$ $\quad W = \int pdV$ $\quad e = \frac{|W_{net}|}{|Q_{hot}|} \leq 1 - \frac{T_{cold}}{T_{hot}}$