

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

Component versions of vector OSEs are also OSEs.

Kinematics: $\vec{r} = x\hat{i} + y\hat{j}$ $\vec{v} = \frac{d\vec{r}}{dt}$ $\vec{a} = \frac{d\vec{v}}{dt}$

Constant $\vec{a}$: $x = x_0 + v_{0x}t + \frac{1}{2} a_x t^2$ $v_x = v_{0x} + a_x t$ $v_x^2 = v_{0x}^2 + 2 a_x (x - x_0)$
 $y = y_0 + v_{0y}t + \frac{1}{2} a_y t^2$ $v_y = v_{0y} + a_y t$ $v_y^2 = v_{0y}^2 + 2 a_y (y - y_0)$

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

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

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

Friction: $f_s \leq \mu_s N$ $f_k = \mu_k N$

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

Dot Product: $\vec{A} \cdot \vec{B} = AB \cos \theta_{AB} = AB_{\parallel A} = A_{\parallel B} B = A_x B_x + A_y B_y + A_z B_z$

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

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

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

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

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

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

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

System: $\vec{P} = \Sigma \vec{p}_n$ $\vec{P}_f - \vec{P}_i = \vec{J}_{net \text{ ext}}$

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

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

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

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

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

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

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

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

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

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

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

Mass-spring: $\omega = \sqrt{\frac{k}{m}}$ $T = 2\pi\sqrt{\frac{m}{k}}$

Simple pendulum: $T = 2\pi\sqrt{\frac{L}{g}}$ Physical pendulum: $T = 2\pi\sqrt{\frac{I}{mgd}}$

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

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

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

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

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

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

$\Delta U = nc_v\Delta T$ adiabatic: $pV^{\gamma} = \text{const}, \gamma = c_p/c_v$

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