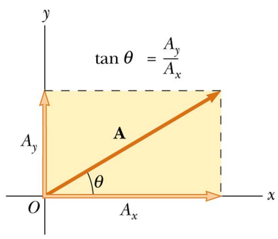

$$\vec{A}=\vec{A}_x+\vec{A}_y \qquad A_x=A\cos\theta \qquad A_y=A\sin\theta \qquad A=\sqrt{A_x^2+A_y^2}$$

$$\theta=\tan^{-1}\left(\frac{A_y}{A_x}\right) \qquad \tan\theta=\frac{A_y}{A_x}$$

$$v_{avg}=\frac{\Delta x}{\Delta t}=\frac{x_f-x_i}{t_f-t_i} \qquad v_{inst}\equiv\lim_{\Delta t\to 0}\frac{\Delta x}{\Delta t}$$

$$a_{avg}=\frac{\Delta v}{\Delta t}=\frac{v_f-v_i}{t_f-t_i} \qquad a_{inst}\equiv\lim_{\Delta t\to 0}\frac{\Delta v}{\Delta t}$$

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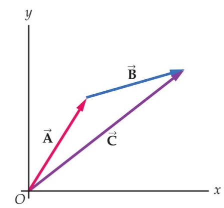
$$\Delta x=\upsilon_0 t+\tfrac{1}{2}at^2 \qquad \Delta x=\tfrac{1}{2}(\upsilon_0+\upsilon)t \qquad \upsilon=\upsilon_0+at \qquad \upsilon^2=\upsilon_0^2+2a\,\Delta x$$

$$\Delta\vec{r}=\vec{r}_f-\vec{r}_i \qquad \vec{v}_{avg}=\frac{\Delta\vec{r}}{\Delta t} \qquad \vec{v}_{inst}\equiv\lim_{\Delta t\to 0}\frac{\Delta\vec{r}}{\Delta t}$$

$$\vec{a}_{avg}=\frac{\Delta\vec{v}}{\Delta t} \qquad \vec{a}_{inst}\equiv\lim_{\Delta t\to 0}\frac{\Delta\vec{v}}{\Delta t}$$

$$\vec{C}=\vec{A}+\vec{B} \qquad C_x=A_x+B_x \qquad C_y=A_y+B_y$$



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$$v_x=v_{0x}+a_xt \qquad \Delta x=v_{0x}t+\tfrac{1}{2}a_xt^2 \qquad v_x^2=v_{0x}^2+2a_x\,\Delta x$$

$$v_y=v_{0y}+a_yt \qquad \Delta y=v_{0y}t+\tfrac{1}{2}a_yt^2 \qquad v_y^2=v_{0y}^2+2a_y\,\Delta y$$

projectile motion

$$v_y=v_0\sin\theta_0-g\,t \qquad v_x=v_{0x}=v_0\cos\theta_0 \qquad \Delta y=v_0\sin\theta_0\,t-\tfrac{1}{2}g\,t^2 \qquad \Delta x=v_{0x}t \qquad R=\sin(2\theta_0)v_o^2/g$$

$$At^2+Bt+C=0;\quad t=\frac{-B\pm\sqrt{B^2-4AC}}{2A}$$

g = 9.80 m/s^2 down $\qquad \vec{V}_{AB}=\vec{V}_{AC}+\vec{V}_{CB}$

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$\vec{a}=\dfrac{\Sigma\vec{F}}{m}$; $\Sigma\vec{F}=m\vec{a}$; $\vec{F}_{12}=-\vec{F}_{21}$; weight $W=mg$; $f_k=\mu_k n$; $f_s^{max}=\mu_s n$; $F_D=\tfrac{1}{2}C\rho Av^2$;

$v_t=\sqrt{2mg/(C\rho A)}$; $\rho_{air}=1.21\ kg/m^3$; $W=(F\cos\theta)d$; $K=\tfrac{1}{2}m\upsilon^2$; $W_{total}=\tfrac{1}{2}m\upsilon_f^2-\tfrac{1}{2}m\upsilon_0^2$; $U_g=mgy$;

$F_s=-kx$; $U_s=\tfrac{1}{2}kx^2$; mech. energy $E=U+K$; $W_C=U_i-U_f$; $W_{nc}=E_f-E_0$; $W_{total}=W_C+W_{nc}$;

$\overline{P}=\dfrac{W}{t}=F\overline{\upsilon}$; centrip. $a_{CP}=v^2/R$; $f_{CP}=mv^2/R$; stress=modulus*strain, e.g. $F/A=Y(\Delta L/L_0)$

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impulse $\vec{I}=\vec{F}_{av}\Delta t=\Delta\vec{p}$; $\vec{p}=m\vec{v}$; $p_x=mv_x$; $p_y=mv_y$; $\vec{F}=\Delta\vec{p}/\Delta t$; $\sum\vec{p}=$ const. when $\sum\vec{F}_{ext}=0$;

perfect inelas. coll. (stuck – together) $\Rightarrow$ $\vec{v}_f=\dfrac{m_1\vec{v}_{01}+m_2\vec{v}_{02}}{m_1+m_2}$; elastic 1D, m_2 initially as rest $\Rightarrow$ $v_{1f}=\dfrac{m_1-m_2}{m_1+m_2}v_{1i}$; $v_{2f}=\dfrac{2m_1}{m_1+m_2}v_{1i}$;

$x_{CM}=\dfrac{\sum m_ix_i}{\sum m_i}$; $y_{CM}=\dfrac{\sum m_iy_i}{\sum m_i}$; $\vec{v}_{CM}=\dfrac{\sum m_i\vec{v}_i}{\sum m_i}$; $\vec{a}_{CM}=\dfrac{\sum m_i\vec{a}_i}{\sum m_i}=\dfrac{\sum\vec{F}_{ext}}{M}$; thrust $=\left|v_e\dfrac{\Delta M}{\Delta t}\right|$;

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θ(in radians) $=\dfrac{s}{r}$; $\omega_{av}=\dfrac{\Delta\theta}{\Delta t}=\dfrac{\theta-\theta_0}{t-t_0}$; $\alpha_{av}=\dfrac{\Delta\omega}{\Delta t}=\dfrac{\omega-\omega_0}{t-t_0}$; $\omega=\lim\limits_{\Delta t\to 0}\dfrac{\Delta\theta}{\Delta t}$; $\alpha=\lim\limits_{\Delta t\to 0}\dfrac{\Delta\omega}{\Delta t}$;

$\upsilon_t=r\omega$; $a_t=r\alpha$; $\theta=\omega_0t+\tfrac{1}{2}\alpha t^2$; $\theta=\tfrac{1}{2}(\omega_0+\omega)t$; $\omega=\omega_0+\alpha t$; $\omega^2=\omega_0^2+2\alpha\theta$; $a=\sqrt{a_c^2+a_t^2}$;

$a_c=\upsilon^2/r=\omega^2r$; $F_c=m\upsilon^2/r$; $\tau=rF\sin\theta$; $\tau=mr^2\alpha$; $\sum\tau=\Delta L/\Delta t=I\alpha$; $I=\sum mr^2$;

$W_R=\tau\theta$; $K_R=\tfrac{1}{2}I\omega^2$; $L_i=L_f$; $L=I\omega$; $\vec{L}=\vec{r}\times\vec{p}=lp=mrv\sin\theta$; equilib. $\Rightarrow$ $\sum\vec{F}=0$ and $\sum\vec{\tau}=0$;

$I=MR^2$ *thin cylindrical shell* ; $I=\tfrac{1}{2}MR^2$ *solid disk* ;
$I=\tfrac{2}{3}MR^2$ *thin spherical shell* ; $I=\tfrac{2}{5}MR^2$ *solid sphere* ; $E=\tfrac{1}{2}I\omega^2+\tfrac{1}{2}mv^2+\tfrac{1}{2}kx^2+mgy$

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$F_G = \frac{-GM\ m}{r^2}$;G=6.67x10^{-11} N m^2 kg^{-2}; R$_E$=6.38x10^6 m; M$_E$=5.98x10^{24} kg; $g = \frac{GM_E}{R_E^2}$; $U = \frac{-GM_E m}{r}$;

orbit $\upsilon = \sqrt{\frac{GM_S}{r}}$; $T = \frac{2\pi r^{3/2}}{\sqrt{GM_S}}$; Kepler: $T^2 = \left(\frac{4\pi^2}{GM_S}\right) r^3$; $\upsilon_{esc} = \sqrt{\frac{2GM_E}{R_E}}$;

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SHM $2\pi f = \omega = \sqrt{\frac{k}{m}}$; $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$; $f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$; $x = A\cos(\omega t + \theta_0)$; $\begin{matrix} v = -A\omega\sin(\omega t + \theta_0) \\ a = -A\omega^2\cos(\omega t + \theta_0) \end{matrix}$;

$\begin{matrix} v_{max} = A\omega \\ a_{max} = A\omega^2 = kA/m \end{matrix}$; $E_{total} = \frac{1}{2}kA^2$; $v = \pm\sqrt{\frac{k}{m}(A^2 - x^2)}$; pend. $\omega = \sqrt{\frac{g}{L}}$; $T = 2\pi\sqrt{\frac{L}{g}}$; $T = 2\pi\sqrt{\frac{I}{mgl}}$;

damp $f_F = -bv$; $x = A_0 e^{-bt/2m}\cos(\omega_0 t + \theta_0)$; crit.damp $b/(2m) = \omega_0 = \sqrt{k/m}$; $\omega_{res}^2 = \omega_0^2 - b^2/(2m^2)$

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$v = \frac{\lambda}{T} = \lambda f$; $v = \sqrt{\frac{F}{m/L}}$; $y(x,t) = A\cos\left(\frac{2\pi x}{\lambda} - \frac{2\pi t}{T}\right)$; $v = 343\, m/s$; $I = \frac{P}{A}$; $I = \frac{P}{4\pi r^2}$; $\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$;

$\beta = 10dB \times \log\left(\frac{I}{I_0}\right)$; $I = I_0 \cdot 10^{\beta/10}$; $I_0 = 1.0\times10^{-12} W/m^2$; $f_O = f_S\left(\frac{v \pm v_O}{v \mp v_S}\right)$; $r_2 - r_1 = n\lambda$ construc.;

$r_2 - r_1 = (n + \frac{1}{2})\lambda$ destruct.; stand.wave.string $f_1 = v/(2L)$; $f_2 = 2f_1$, $f_3 = 3f_1$;

$f_n = nf_1 = \frac{nv}{2L}, n = 1,2,3,...$ *open both ends*; $f_n = \frac{nv}{4L}, n = 1,3,5,...$ *open one end*; $f_{beat} = |f_1 - f_2|$;

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$\rho = M/V$; $\rho = (Specific\ Gravity)\cdot\rho_{water}$; $\rho_{water} = 1000 kg/m^3$; $P = F/A$; $Pa = N/m^2$; $P = P_{at} + \rho gh$;

$P_{at} = 1.01\times10^5 Pa$; $P_{gauge} = P - P_{at}$; buoyant $F_b = \rho_{fluid} V_{displaced}\, g$; $\rho_1 v_1 A_1 = \rho_2 v_2 A_2$; Bernoulli

$P + \frac{1}{2}\rho v^2 + \rho gh = const.$; $v = \sqrt{2gh}$; $P_1 - P_2 = 8\pi\eta vL/A$; $dV/dt = (P_1 - P_2)\pi r^4/(8\eta L)$

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$T_C = T - 273.15$; $T_F = \frac{9}{5}T_C + 32$; $T_C = \frac{5}{9}(T_F - 32)$; $\Delta L = \alpha L_0 \Delta T$; $L - L_0 = \alpha L_0 (T - T_0)$; $\Delta V = \beta V_0 \Delta T$;

$V = V_0 + \beta V_0 (T - T_0)$; $\beta = 3\alpha$; 1 cal = 4.186 J; heat cap. $C \equiv \frac{Q}{\Delta T}$; spec. heat $c \equiv \frac{Q}{m\Delta T}$; $Q = kA\frac{\Delta T}{L}t$;

$P = \sigma A e T^4$; $\wp_{net} = \sigma A e\left(T^4 - T_0^4\right)$;

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$PV = nRT = Nk_B T$; $N_A = 6.02\times10^{23}\, part./mole$; $R = 8.31 J/mol\cdot K$; $k_B = R/N_A = 1.38\times10^{-23} J/K$;

$\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_B T$; $U = \frac{3}{2}nRT$; $v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$; $W = -P\Delta V$; $C_v = \frac{3}{2}R$; $\Delta U = nC_v\Delta T$; adiab.

$PV^\gamma = const.$; latent heat $Q \equiv \pm mL$; $\gamma = C_p/C_v$; $W_{env} = nRT\ln\left(V_f/V_i\right)$; $W_{env} = |Q_h| - |Q_c|$;

$e = \frac{W_{env}}{|Q_h|} = \frac{|Q_h| - |Q_c|}{|Q_h|} = 1 - \frac{|Q_c|}{|Q_h|}$; $\frac{|Q_c|}{|Q_h|} = \frac{T_c}{T_h}$; $e_C = 1 - \frac{T_c}{T_h}$; $\Delta S \equiv \frac{Q_r}{T}$; $S = k_B \ln W$;

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