Mechanics Equations

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Version 5.1

Units:

Joule J = kg m^2/s^2

Newton N = kg m/s^2

Pascal Pa = N/m^2

Watt W = J/s

1 J = 1 N m

Some Metric Prefixes:

kilo k = 10^3

centi c = 10^{-2}

mili m = 10^{-3}

micro $\mu = 10^{-6}$

nano n = 10^{-9}

pico p = 10^{-12}

Constant Acceleration:

$v(t) = v_0 + at$

$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$

$v(t)^2 = v_0^2 + 2a(x(t) - x_0)$

Forces:

$\sum \vec{F} = m\vec{a}$

$\vec{F_{12}} = -\vec{F_{21}}$

$F_{f(k)} = \mu_k F_N$

$F_{f(s)} \leq \mu_s F_N$

$F_g = mg$

$F_G = \frac{Gm_1m_2}{R^2}$

$\vec{F_e} = -k\Delta\vec{x}$

$G = 6.67 \times 10^{-11}$N m^2/kg^2

$g = 9.8$m/s^2

$a_c = v^2/R = \omega^2 R$

$\sum \vec{F} = \frac{d\vec{p}}{dt}$

Work, Energy and Momentum:

$W = Fd\cos(\theta)$

$W = Fd_{\|} = F_{\|}d$

$W = \int \vec{F}(t)dt$

$W = \vec{F} \cdot \vec{d}$

$E_k = \frac{1}{2}mv^2$

$\Sigma W = \Delta E_k$

$U_g = mg\Delta h$

$U_G = \frac{-Gm_1m_2}{R}$

$U_e = \frac{1}{2}k\Delta x^2$

$\Sigma E_f - \Sigma E_o = \Sigma W_{NC}$

$\vec{p} = m\vec{v}$

$\Sigma\vec{p_0} = \Sigma\vec{p_f}$

$\vec{J} = \Delta\vec{p}$

$\vec{J} = \int \vec{F}(t)dt$

$x_{CM} = \sum m_i x_i$

Power $P = W/t$

Angular Quantities:

$R\theta = d$

$R\omega = v_t$

$R\alpha = a_t$

Constant Angular Acceleration:

$\omega(t) = \omega_0 + \alpha t$

$\theta(t) = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$

$\omega(t)^2 = \omega_0^2 + 2\alpha(\theta(t) - \theta_0)$

Torque, Angular Momentum:

$\tau = rF\sin(\theta) = rF_\perp = r_\perp F$

$\vec{\tau} = \vec{r} \times \vec{F}$

$I = \Sigma m_i r_i^2$

$I_{new} = I_{cm} + mh^2$

$I = \int r^2 dm$

$\Sigma\tau = I\alpha$

$L = I\omega = rp\sin\theta$

$\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$

$\Sigma\vec{L_0} = \Sigma\vec{L_f}$

$E_{krot} = \frac{1}{2}I\omega^2$

$T = 1/f$

$\omega = 2\pi f$

$v = \frac{2\pi r}{T}$

Pressure/Fluids:

1 atm = 1.013×10^5 Pa

1 torr = 1 mm Hg

760 torr = 1 atm

1 bar = 10^5 Pa

$\rho = m/V$
$P = F/A$
$P(d) = P_0 + \rho g d$
$P + 1/2\rho v^2 + \rho g h = \text{const}$
$A_1 v_1 = A_2 v_2$
$F_B = \rho_{fluid} V_{disp} g$
Oscillations:
$x(t) = A\sin(2\pi t/T)$ or
$x(t) = A\cos(2\pi t/T)$
$T_s = 2\pi\sqrt{\frac{m}{k}}$
$T_p = 2\pi\sqrt{\frac{l}{g}}$
Waves:
$y(x,t) = A\sin(kx \pm \omega t)$ or
$x(t) = A\cos(kx \pm \omega t)$
$T = 1/f = 2\pi/\omega$
$k = 2\pi/\lambda$ and $\omega = 2\pi f = 2\pi/T$
$v = f\lambda$
Sound:
$v_{sound} = 343$ m/s
$\beta = 10\log_{10}(I/I_0)$
$I_0 = 1\times10^{-12}\mathrm{W/m^2}$
$f' = \frac{f_0}{1\pm\frac{v_s}{v}}$
$f' = f_0(1 \pm \frac{v_o}{v})$
$f_b = |f_1 - f_2|$
Temperature:
T(K) = T(C) + 273.15 K
$\Delta L = \alpha L_0 \Delta T$
$L = L_0(1+\alpha\Delta T)$
$PV = nRT$
$PV = Nk_BT$
$\bar{E_k} = E_{Kavg} = \frac{1}{2}m\bar{v^2} = \frac{3}{2}k_BT$
$\frac{1}{2}m\bar{v_x^2} = \frac{1}{2}k_BT$
R = 8.315 J/mol K = 1.99 cal/mol K = 0.0821 atm liter/mol K
$k_B = 1.38\times10^{-23}\mathrm{J/K}$
$N_A = 6.022\times10^{23}$
$R = N_A k_B$
$N = nN_A$
Heat:
$Q = cm\Delta T = C\Delta T$
$Q = Lm$
$0 = \Delta Q_1 + \Delta Q_2$
Thermodynamics:
$\Delta U = Q - W$
$W = P\Delta V$
$W = \int P(V)dV$
$\Delta S = Q/T$
$\Delta S = \int Q(T)/TdT$
Trig:
$\sin\theta = \text{opp/hyp}$
$\cos\theta = \text{adj/hyp}$
$\tan\theta = \text{opp/adj}$
Quadratic:
Given: $ax^2 + bx + c = 0$
Then: $x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$
Areas, Volumes:
Sphere:
Volume = $4/3\pi r^3$, Area = $4\pi r^2$
Cylindar:
Volume = $\pi r^2 h$, Area = $2\pi r h + 2\pi r^2$
Circle:
Area = πr^2, circumfrence = $2\pi r$
Moments of Inertia
Passing Through Center of Mass:
Thin Disk Perpendicular to Plane
$I = \frac{1}{2}mr^2$
Sphere
$I = \frac{2}{5}mr^2$
Thin Rod Perpendicular to Length:
$I = \frac{1}{12}mL^2$
Thin Plate Perpendicular to Plane:
$I = \frac{1}{12}m(w^2 + L^2)$