1D Kinematics

$$v_f = v_0 + at \tag{1}$$
$$\Delta x = \frac{\Delta v}{2} t \tag{2}$$
$$\Delta x = v_0 t + \frac{a}{2} t^2 \tag{3}$$
$$v_f^2 = v_0^2 + 2a\Delta x \tag{4}$$

2D Projectile

$$t_f = \frac{2v_0 \sin(\theta)}{g} \tag{5}$$
$$t_f = \frac{v_0 \sin(\theta) + \sqrt{v_0^2 \sin^2(\theta) + 2gy_0}}{g} \tag{6}$$
$$R = \frac{v_0^2 \sin(2\theta)}{g} \tag{7}$$
$$R = \frac{v_0 \cos(\theta)}{g}\left(v_0 \sin(\theta) + \sqrt{v_0^2 \sin^2(\theta) + 2gy_0}\right) \tag{8}$$
$$R = \sin(2\theta)\frac{v_0^2}{2g}\left(1 + \sqrt{1 + \frac{2gy_0}{v_0^2 \sin^2(\theta)}}\right) \tag{9}$$
$$H_{max} = y_0 + \frac{v_0^2 \sin^2(\theta)}{2g} \tag{10}$$
$$\theta = \frac{1}{2}\arcsin\left(\frac{g\Delta x}{v_0^2}\right) \tag{11}$$
$$\theta = 90 - \frac{1}{2}\arcsin\left(\frac{g\Delta x}{v_0^2}\right) \tag{12}$$
$$\theta = \arctan\left(\frac{y_f}{x_f} + \sqrt{\frac{y_f^2}{x_f^2} + 1}\right) \tag{13}$$
$$v_0 = \sqrt{\frac{x^2 g}{x \sin(2\theta) - 2y\cos^2(\theta)}} \tag{14}$$

Circular Motion

$$a_{tot} = \sqrt{a_r^2 + a_t^2} \tag{15}$$
$$\omega = \frac{2\pi}{T} \tag{16}$$
$$v = \omega r \tag{17}$$
$$a_r = \omega^2 r \tag{18}$$
$$a_r = \frac{v^2}{r} \tag{19}$$
$$F_c = a_r m \tag{20}$$
$$\alpha = \frac{a_t}{r} \tag{21}$$

One can use all of the 1D Kinematics equations with:

$$x = \theta$$
$$v_i = \omega_i$$
$$a = \alpha$$

Forces

$$\Sigma \vec{F} = m\vec{a} \tag{22}$$

Energy

$$K = \frac{1}{2}mv^2 \tag{23}$$
$$K = \frac{1}{2}I\omega^2 \tag{24}$$
$$U = mgh \tag{25}$$
$$U = \frac{1}{2}kx^2 \tag{26}$$
$$U = mgy_{cm} \tag{27}$$
$$E_{th} = fs \tag{28}$$
$$W = F \cdot D = |F||D|\cos(\theta) \tag{29}$$
$$F \cdot D = F_x D_x + F_y D_y ... \tag{30}$$

Momentum

$$\Delta\rho = J \tag{31}$$

$$J = \int F(t)dt \tag{32}$$

$$\text{Elastic} \tag{33}$$

$$v_1 = \frac{m_1 - m_2}{m_1 + m_2}u_1 + \frac{2m_2}{m_1 + m_2}u_2 \tag{34}$$

$$v_2 = \frac{m_1 - m_2}{m_1 + m_2}u_2 + \frac{2m_1}{m_1 + m_2}u_1 \tag{35}$$

$$\text{Inelastic Stick} \tag{36}$$

$$v = \frac{m_1}{m_1 + m_2}u_1 \tag{37}$$

Moment of Inertia

$$x_{cm} = \frac{\sum mx}{\sum m} \tag{38}$$

$$I = I_{cm} + Md^2 \tag{39}$$

$$I_{disk} = \frac{1}{2}mr^2 \tag{40}$$

$$I_{hoop} = mr^2 \tag{41}$$

$$I_{sphere} = \frac{2}{5}mr^2 \tag{42}$$

$$I_{sphere\_hollow} = \frac{2}{3}mr^2 \tag{43}$$

$$I_{rod\_center} = \frac{1}{12}ml^2 \tag{44}$$

$$I_{rod\_end} = \frac{1}{3}ml^2 \tag{45}$$

Torque

$$\tau = rF\sin(\theta) \tag{46}$$

$$\tau = r \times F = rF\sin(\theta) \tag{47}$$

$$\tau = r_{moment}F \tag{48}$$

$$\tau = I\alpha \tag{49}$$

$$P = \tau\omega \tag{50}$$

Angular Momentum

$$L = \rho \times r \tag{51}$$
$$L = I\omega \tag{52}$$

Gravity

$$G = 6.67 \cdot 10^{-11} \tag{53}$$
$$F_g = \frac{GMm}{r^2} \tag{54}$$
$$U = -\frac{GMm}{r} \tag{55}$$
$$K = \frac{GMm}{2r} \tag{56}$$
$$E = -\frac{GMm}{2r} \tag{57}$$
$$v_{esc} \geq \sqrt{\frac{2GM}{r}} \tag{58}$$
$$v = \sqrt{\frac{GM}{r}} \tag{59}$$
$$T = 2\pi\sqrt{\frac{a^3}{GM}} \tag{60}$$

Simple Harmonic Motion

$$F = -kx \tag{61}$$

$$\omega = \sqrt{\frac{k}{m}} \tag{62}$$

$$x(t) = x_0 \cos\left(\sqrt{\frac{k}{m}}t\right) + \frac{v_0}{\sqrt{\frac{k}{m}}} \sin\left(\sqrt{\frac{k}{m}}t\right) \tag{63}$$

$$x(t) = A\cos\left(\omega t - \phi\right) \tag{64}$$

$$c_1 = x_0 \tag{65}$$

$$c_2 = \frac{v_0}{\omega} \tag{66}$$

$$\tan\left(\phi\right) = \frac{c_1}{c_2} \tag{67}$$

$$v = \omega\sqrt{A^2 - x^2} \tag{68}$$

$$a = \omega^2 AK(t) = \frac{1}{2}kA^2 \sin^2(\omega t - \phi) \tag{69}$$

$$U(t) = \frac{1}{2}kA^2 \cos^2(\omega t - \phi) \tag{70}$$

$$E = \frac{1}{2}kA^2 \tag{71}$$

$$T = 2\pi\sqrt{\frac{l}{g}} \tag{72}$$

$$\omega = \sqrt{\frac{mgl}{I}} \tag{73}$$

Fluids

$$\rho = \frac{m}{V} \tag{74}$$

$$p = \frac{F}{A} \tag{75}$$

$$F_b = \rho g V \tag{76}$$

$$v_1 A_1 = v_2 A_2 \tag{77}$$

$$p = \rho g d + P_0 \tag{78}$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2 \tag{79}$$

Thermodynamics

$$R = 8.314 \tag{80}$$
$$N_{av} = 6.022 \cdot 10^{23} \tag{81}$$
$$k_B = 1.38 \cdot 10^{-23} \tag{82}$$
$$pV = nRT \tag{83}$$
$$pV = Nk_BT \tag{84}$$
$$pV^{\gamma} = constant \tag{85}$$
$$TV^{\gamma-1} = constant \tag{86}$$
$$\gamma = \frac{C_p}{C_v} \tag{87}$$
$$C_p = C_v + R \tag{88}$$
$$\Delta E = W + Q \tag{89}$$
$$\Delta E = nC_v\Delta T \tag{90}$$
$$Q = nC_x\Delta T \tag{91}$$

Periodic Table

https://www.thoughtco.com/thmb/67-ZE4diyATe7qUfN0zBNfZ-gH0=/1920x0/filters:no_upscale():max_bytes(150000):strip_icc():format(webp)/PeriodicTableoftheElements-5c3648e5jpg

Substance	ρ (kg/m^3)	c (J/kg K)
Air at STP*	1.29	
Ethyl alcohol	790	2400
Gasoline	680	
Glycerin	1260	
Mercury	13,600	140
Oil (typical)	900	
Seawater	1030	
Water	1000	4190
Aluminum	2700	900
Copper	8920	385
Gold	19,300	129
Ice	920	2090
Iron	7870	449
Lead	11,300	128
Silicon	2330	703

*Standard temperature (0°C) and pressure (1 atm)

	Monoatomic	Diatomic
E_{th}	$\frac{3}{2}nRT$	$\frac{5}{2}nRT$
C_V	$\frac{3}{2}R$	$\frac{5}{2}R$
C_P	$\frac{5}{2}R$	$\frac{7}{2}R$
γ	5/3	7/5

Special Case Processes	W	Q	ΔE
isochoric	0	ΔE $nC_v\Delta T$	Q $nC_v\Delta T$
isobaric	-pΔV	$nC_p\Delta T$	$nC_v\Delta T$
isothermal	$-Q$ $nRT\ ln\frac{V_i}{V_f}$	-W	0
adiabatic	ΔE	0	W $nC_v\Delta T$
cyclic	$-Q_{tot}$	$-W_{tot}$	0