Linear uniform motion: $x_f = x_i + v_i \cdot \Delta t$

Linear motion with constant acceleration:

$v_f = v_i + a \cdot \Delta t$

$x_f = x_i + v_i \cdot \Delta t + \frac{1}{2}a(\Delta t)^2$

$x_f = x_i + \frac{v_f^2 - v_i^2}{2a}$

$v_{avr} = \frac{x_f - x_i}{\Delta t} = \frac{v_f + v_i}{2}$

Projectile motion:

$v_{xf} = v_{xi}$

$v_{yf} = v_{yi} - g \cdot \Delta t$

$y_f = y_i + v_{yi} \cdot \Delta t - \frac{1}{2}g(\Delta t)^2$

$y_f = y_i - \frac{v_{yf}^2 - v_{yi}^2}{2g}$

$x_f = x_i + v_{xi} \cdot \Delta t$

Angular uniform motion: $\theta_f = \theta_i + \omega_i \cdot \Delta t$

Angular motion with constant acceleration:

$\omega_f = \omega_i + a \cdot \Delta t$

$\theta_f = \theta_i + \omega_i \cdot \Delta t + \frac{1}{2}\alpha(\Delta t)^2$

$\theta_f = \theta_i + \frac{\omega_f^2 - \omega_i^2}{2\alpha}$

$\omega_{avr} = \frac{\theta_f - \theta_i}{\Delta t} = \frac{\omega_f + \omega_i}{2}$

Connection between linear and angular variables: $s = \theta \cdot r \quad v = \omega \cdot r \quad a = \alpha \cdot r$ **Centripetal acceleration:** $a = \frac{v^2}{r} = \omega^2 r$

Newtons second law: **Linear** motion $\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a}$ **Angular** motion $\tau_{net} = \sum_i \tau_i = I \cdot \alpha$

Friction force: $f_s = \mu_s \cdot N$, $f_k = \mu_k \cdot N$ Hooks law: $f = -k \cdot \Delta x$ **Torque:** $\tau = F \cdot r \sin\theta = F \cdot r_{arm}$

Linear momentum: $\vec{p} = m \cdot \vec{v}$ Impulse: $\vec{I} = \vec{F} \cdot \Delta t$ Impulse-momentum: $\Delta\vec{p} = \vec{I}$ Angular momentum: $L = I \cdot \omega$

Conservation of momentum: **linear:** $\sum_k \vec{p}_{ki} = \sum_k \vec{p}_{kf}$ **angular:** $\sum_k L_{ki} = \sum_k L_{kf}$

Kinetic energy: **linear:** $K = \frac{mv^2}{2}$ **angular:** $K = \frac{I\omega^2}{2}$ **Work:** $W = F \cdot d \cos\theta$ or $W = \tau \cdot \theta$

Potential energy: **gravity:** $U = mgy$ **elastic:** $U = \frac{k(\Delta x)^2}{2}$ Power: $P = \frac{\Delta W}{\Delta t} = F \cdot v$

Conservation of energy: $\Delta K + \Delta U = K_f - K_i + U_f - U_i = W$ Work-Energy Theorem: $W_{net} = K_f - K_i = \Delta K$

Elastic Collision: $m_1\vec{v}_{1i} + m_2\vec{v}_{2i} = m_1\vec{v}_{1f} + m_2\vec{v}_{2f}$ $\frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$ $v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$

Moments of inertia:

Point-like object	distance from axis R	mR^2
Thin hoop, radius R	axis through center	mR^2
Solid cilinder, radius R	axis through center	$\frac{1}{2}mR^2$
Hollow cilinder, inner radius R_1 , outer radius R_2	axis through center	$\frac{1}{2}m(R_1^2 + R_2^2)$
Uniform sphere, radius R	axis through center	$\frac{2}{5}mR^2$
Thin spherical shell radius R	axis through center	$\frac{2}{3}mR^2$
Long uniform rod, length L	axis through center	$\frac{1}{12}mL^2$
Long uniform rod, length L	axis through end	$\frac{1}{3}mL^2$

Coefficient of Friction

	μ_s	μ_k
Steel on steel (dry)	0.8	0.6
Steel on steel (lubricated)	0.1	0.05
Aluminum on steel	0.61	0.47
Copper on steel	0.53	0.36
Rubber on concrete	1.0	0.8
Wood on wood	0.5	0.2
Wood on snow	0.12	0.06
Ice on ice	0.1	0.03
Synovial joints in humans	0.01	0.003

Center-of-mass: $x_{cm} = \frac{\sum_i m_i x_i}{M}$ **Gravity force:** $F = G\frac{m_1 m_2}{r^2}$ **Gravity potential energy:** $U = -G\frac{m_1 m_2}{r}$

Third Keplers Law: $T^2 = \left(\frac{4\pi^2}{GM_e}\right)a^3$ **Period** of rotation: $T = \frac{2\pi r}{v}$

Oscillations: $x(t) = A\cos(\omega t + \phi_0)$ $v(t) = -\omega A \sin(\omega t + \phi_0)$ $a(t) = -\omega^2 A \cos(\omega t + \phi_0)$

$\omega = 2\pi f$ $f = \frac{1}{T}$ $E_{tot} = \frac{1}{2}kA^2 = \frac{1}{2}m\omega^2 A^2 = \frac{1}{2}mv_{max}^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$ $\omega = \sqrt{\frac{k}{m}}$ $\omega = \sqrt{\frac{g}{L}}$

Mass density: $\rho = \frac{m}{V}$ Pressure: $p = \frac{F}{A}$ Hydrostatic pressure: $p = p_0 + \rho g h$ Boyant force: $F_B = \rho_f g V_{submerged}$

Continuity: $v_i \cdot A_i = v_f \cdot A_f$ Bernoullis equation: $p_i + \frac{1}{2}\rho v_i^2 + \rho g y_i = p_f + \frac{1}{2}\rho v_f^2 + \rho g y_f$

Tensile stress=$\frac{F}{A}$ strain=$\frac{\Delta L}{L_0}$ $\frac{F}{A} = Y\frac{\Delta L}{L_0}$ Volume stress=$p = \frac{F}{A}$ $p = -B\frac{\Delta V}{V_0}$

Density:

Substance	$\rho(kg/m^3)$	Substance	$\rho(kg/m^3)$	Substance	$\rho(kg/m^3)$
Air	1.28	Aluminum	2700	Copper	8920
Ethyl alcohol	790	Gasoline	680	Glycerin	1260
Gold	19,300	Helium gas	0.18	Iron	7870
Lead	11,300	Mercury	13,600	Oil (typical)	900
Seawater	1030	Silicon	2330	Water (liquid)	1000
Water (solid)	920				

Elastic properties:

Substance	$Y(N/m^2)$	$B(N/m^2)$
Aluminum	7×10^{10}	7×10^{10}
Concrete	3×10^{10}	
Copper	11×10^{10}	14×10^{10}
Mercury		3×10^{10}
Plastic	0.3×10^{10}	
Steel	20×10^{10}	16×10^{10}
Water		0.2×10^{10}
Wood	1×10^{10}	

Specific heat:

Substance	$c(J/kg \cdot K))$	$c(cal/g \cdot K))$
Aluminum	900	0.22
Copper	390	0.093
Ethyl alcohol	2400	0.58
Iron/Steel	450	0.11
Silver	230	0.056
Lead	130	0.031
Mercury	140	0.033
Ice	2100	0.5
Water	4190	1
Wood	1700	0.4

Expansion coefficient:

Substance	$\alpha(C^\circ)^{-1}$	$\beta(C^\circ)^{-1}$
Aluminum	25×10^{-6}	75×10^{-6}
Brass	19×10^{-6}	56×10^{-6}
Copper	17×10^{-6}	50×10^{-6}
Ethyl alcohol		950×10^{-6}
Iron/Steel	12×10^{-6}	35×10^{-6}
Gold	14×10^{-6}	42×10^{-6}
Lead	29×10^{-6}	87×10^{-6}
Mercury		180×10^{-6}
Glass	9×10^{-6}	27×10^{-6}
Water		210×10^{-6}

Atomic mass number=number of protons + number of neutrons

Number of moles $n = \frac{N}{N_A} = \frac{M}{\mu}$ $k = \frac{R}{N_A}$ Temperature: $T_F = \frac{9}{5}T_C + 32^\circ$ $T = T_C + 273$

Ideal gas law: $pV = nRT = NkT$ $\frac{1}{2}m\bar{v}^2 = \frac{3}{2}kT$ $v_{rms} = \sqrt{\frac{3kT}{m}}$

Internal energy: monoatomic $U = \frac{3}{2}Nkt = \frac{3}{2}nRT$ diatomic $U = \frac{5}{2}Nkt = \frac{5}{2}nRT$

Work in ideal gas process: $W = -\int\limits_{V_i}^{V_f} pdV$ =area under curve

For isobaric process: $W = -p(V_f - V_i)$ For isothermal process: $W = -nRT\ln\left(\frac{V_f}{V_i}\right)$ For isochoric process: $W = 0$

First law of thermodynamics: $\Delta U = Q + W = Q - W_g$ Efficiency of heat engine: $e = \frac{W_g}{Q_H} = 1 - \frac{Q_L}{Q_H}$

Carnot efficiency: $e = a - \frac{T_L}{T_H}$ COP(refrigerator)=$\frac{Q_L}{W}$ COP(heat pump)=$\frac{Q_H}{W}$

Specific heat: $c = \frac{Q}{m\Delta T}$ Latent heat: $Q = mL$ Thermal conductivity: $\frac{Q}{t} = kA\frac{T_f - T_i}{l}$

Thermal expansion: $\Delta L = \alpha L_0 \Delta T$ $\Delta V = \beta V_0 \Delta T$ $\beta = 3\alpha$ Radiation: $\frac{\Delta Q}{\Delta t} = e\sigma AT^4$

Monatomic gas: $c_V = \frac{3}{2}R$ Diatomic gas: $c_V = \frac{5}{2}R$ Specific heats of gases: $Q_V = nc_V\Delta T$ $Q_P = nc_P\Delta T$ $C_P = C_V + R$

Adiabatic process: $W = nc_V\Delta T$ pV^γ=const $\gamma = \frac{c_P}{c_V}$

Melting/boiling temperatures and heats of transformation

Substance	$T_m(^\circ C)$	$L_f(J/kg)$	$T_b(^\circ C)$	$L_v(J/kg)$
Helium	-269.65	5.23×10^3	-268.93	2.09×10^4
Nitrogen (N_2)	-210	0.26×10^5	-196	1.99×10^5
Oxigen	-218.79	1.38×10^4	-182.97	2.13×10^5
Ethyl alcohol	-114	1.09×10^5	78	8.79×10^5
Mercury	39	0.11×10^5	357	2.96×10^5
Water	0	3.33×10^5	100	22.6×10^5
Lead	328	0.25×10^5	1750	8.58×10^5
Aluminum	660	3.97×10^5	2450	1.14×10^7
Copper	1083	1.34×10^5	1187	5.06×10^6

Molar specific heats of gases (J/molK)

Gas	c_V	c_P
He	20.8	12.5
Ne	20.8	12.5
Ar	20.8	12.5
H_2	28.7	20.4
N_2	29.1	20.8
O_2	29.1	20.9

Constants

Free-fall acceleration g=9.8 m/s^2

Gravitational constant G=6.67×10^{-11} Nm^2/kg^2

Gas constant R=8.31 J/(molK)

Boltzmanns constant k=1.38×10^{-23} J/K

Absolute zero $T_0 = -273^\circ$ C

Avogadros number $N_A = 6.02\times10^{23}$ 1/mol

Speed of sound in the air v=343 m/s

Stefan-Boltzmann constant =5.67×10^8 W/(m^{2}K^4)

Length
1 in = 2.54 cm
1 mi = 1.609 km
1 m = 39.37 in
1 km = 0.621 mi

Time
1 day = 86400 s
1 year = 3.16×10^7 s

Force
1 lb = 4.45 N

Pressure
1 Pa = 1 N/m^2
1 atm = 101,300 Pa
1 atm = 760 mm of Hg
= 1,013 bar
1 atm = 14.7 lb/in^2 = 760 torr

Power
1 hp = 746 W = 550 ftlb/s
1 W = 1 J/s = 0.738 ftlb/s
1 W = 3.42 Btu/h

Mass
1 amu= 1.661×10^{-27} kg

Heat
1 cal = 4.186 J

Astronomical Data

Planetary body	Mean distance from sun (m)	Period (years)	Mass (kg)	Mean radius (m)
Sun			1.99×10^{30}	6.96×10^8
Moon	2.86×10^8*	27.3 days	7.36×10^{22}	1.74×10^6
Mercury	5.79×10^{10}	0.241	3.18×10^{23}	2.43×10^6
Venus	1.08×10^{11}	0.615	4.88×10^{24}	6.06×10^6
Earth	1.50×10^{11}	1.00	5.98×10^{24}	6.37×10^6
Mars	2.28×10^{11}	1.88	6.42×10^{23}	3.37×10^6
Jupiter	7.78×10^{11}	11.9	1.90×10^{27}	6.99×10^7
Saturn	1.43×10^{12}	29.5	5.68×10^{26}	5.85×10^7
Uranus	2.87×10^{12}	84.0	8.68×10^{25}	2.33×10^7
Neptune	4.50×10^{12}	165	1.06×10^{26}	2.21×10^7

* Distance from Earth

Thermal Expansion Coefficients

Material	Linear $(1/^\circ C)$	Material	Volume $(1/^\circ C)$
Aluminum	$24\cdot10^{-6}$	Acetone	$1.5\cdot10^{-4}$
Brass and bronze	$19\cdot10^{-6}$	Benzene	$1.24\cdot10^{-4}$
Concrete	$12\cdot10^{-6}$	Ethyl alchohol	$1.12\cdot10^{-4}$
Copper	$17\cdot10^{-6}$	Gasoline	$9.6\cdot10^{-4}$
Glass (ordinary)	$9\cdot10^{-6}$	Glycerin	$4.85\cdot10^{-4}$
Glass (Pyrex)	$3.2\cdot10^{-6}$	Mercury	$1.82\cdot10^{-4}$
Invar	$0.9\cdot10^{-6}$	Turpentine	$9.0\cdot10^{-4}$
Lead	$29\cdot10^{-6}$	Air at STP	$3.67\cdot10^{-5}$
Steel	$11\cdot10^{-6}$	Helium	$3.665\cdot10^{-5}$